

INTERNATIONAL Chemical Engineering and Process Industries

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Topics of the Month

£45 million spent on chemical plant

IN 1950, capital expenditure by the U.K. chemical industry was the third largest of all industries. In that year the industry's total capital expenditure was £61,000,000. Only two other industries made greater investments: the engineering, shipbuilding and electrical industries expended £66,000,000 and food and drink spent £62,000,000. The chemical industry's 1950 total of £61,000,000 compares with £48,000,000 in 1949 and £39,000,000 in 1948. Of the 1950 total, £45,000,000 was spent on plant and machinery, £13,000,000 on new buildings and works and £3,000,000 on vehicles. Comparable figures for 1948 were: £28,000,000, £8,000,000 and £3,000,000.

This information was obtained by a Government enquiry into capital expenditure by manufacturing industry undertaken early in 1951, and the results appear in detail in the *Board of Trade Journal*. According to the classification used for this survey, the total of workers employed in the chemical industry on September 30, 1950, was 349,000. Capital expenditure per employee in 1950 was £161, a figure second only to mineral oil refining, which had the enormous *per capita* expenditure of £3,320. The survey estimated the total of chemical establishments in Great Britain as 2,149, of which a sample of 249 was approached for information. All but 11 of these firms gave information.

Gamma ray inspection of pressure vessels

UNTIL quite recently pressure vessels with walls 2 in. thick fulfilled all the requirements of the heavy chemical and oil industries. Today, however, there is an increasing demand for vessels with wall thicknesses of 3 in. One of the problems of fabricating vessels of this size is the examination of the welded seams. X-rays are now a routine means of examining seams, but equipment for tackling wall thicknesses of 3 in. is costly. A cheaper alternative to x-rays is gamma rays emitted from radioactive materials.

An account of the successful application of gamma rays to the radiological examination of the seams of welded vessels with 3 in. thick walls has been given by Mr. C. B. Fergusson of G. A. Harvey and Co. (London) Ltd. Radon was chosen in preference to an artificial radio-isotope because it provides a high concentration of radiation in a small area. When the gas is absorbed in a granule of charcoal, 1 mm. cube, a concentration of 6,400 millicuries/mm.³ is achieved.

The charcoal granule with the absorbed radon sealed in a glass tube about 5/32 in. diameter by 1/2 in. long was enclosed in a stainless steel container with a wax seal. It was transported in a solid lead block some 4 in. cube fitted with 3 ft. long carrying handles. It was placed accurately into position in the inside of the vessels at the end of a

14-ft. pole. Panoramic pictures were taken of circumferential seams and four pictures at a time, two on either side, of longitudinal seams. To insure against the risk of failure of any one film, a double film technique was employed, with lead screens. The films were loaded into envelopes and fixed with tape to the side of the vessel.

The quality of the picture obtained with this particular job compared very favourably with that from x-ray machines of the order of 250 kV. However, due to the lack of contrast which is always a difficulty with gamma graphs, considerable experience was required in interpreting and defining the defects. Another obstacle was that where a fault was found in a gamma-graph, stereoscopic pictures for determining its location in the thickness of the plate could not conveniently be made other than by the use of an x-ray machine.

Mr. Fergusson's account, which is an interesting specific example of the use of radioactive materials for industrial radiography, was read at the F.B.I. Conference on the use of radioactive isotopes in industry held last May, the report of which has just appeared. Since this work was carried out radon has given considerable ground to artificial isotopes as sources of gamma rays. That most widely used today is probably cobalt-60 with a half-life of 5.3 years (compared with radon's 3.85 days). Others are tantalum-182 (120 days) and iridium-192 (70 days). Whatever source is used, it is clear that radioactive isotopes have many advantages over x-rays machines for radiographic examinations. They are cheaper, much more portable, and simple to use. Against this, they take longer than x-rays to produce a satisfactory picture and, of course, their use requires the taking of extensive and thorough precautions to guard the health of the radiologists.

New benzole recovery processes

SEVERAL plants in the Ruhr have recently introduced a new catalytic pressure-refining process for benzole, developed by Scholven Chemie AG. The process is claimed to avoid refining losses, to give a high-purity product and to increase benzole recovery by 10% in comparison with the older process based on sulphuric acid. A considerable percentage of the crude benzole produced in the Ruhr coke ovens is being treated by this method in the Scholven plant.

The new process is of great importance in view of the greatly increased demand for benzole in West Germany, mainly for the manufacture of Buna, solvents, plastics, explosives, etc. The Ruhr is now producing only about 300,000 tons of benzole p.a., compared with 400,000 tons before the war, and many pre-war sources of this product have been lost.

More benzole will be available to the chemical industries in the near future. Until now, some 10,000 tons per month have been used to improve the anti-knock properties of motor-fuels. However, petrol to be produced in the German refineries now in course of construction will have a high octane number and will not require improvement.

Another new process, developed in the U.S., is being used with considerable success by the Bergwerksgesellschaft Hibernia of Herne/W. In this process the coking coal in the coke ovens is mixed with petroleum distillation residues prior to firing. By this means benzole recovery is claimed to be increased by 10%, while the resulting gas is said to be several times richer in olefines. This process is hailed as a new source of raw materials for the industries based on the chemistry of ethylene.

Butane as town's gas in Wales

AN interesting development arising from the establishment of a considerable oil refining industry in the U.K. is the use of butane as town's gas by a small gas works at Whitland, North Wales. This experiment, quite new in Britain, was started at the end of January and it has proved so successful that it will be permanently continued at Whitland. Supplies of liquid butane come from Anglo-Iranian's Llandarcy refinery.

Butane has several advantages over coal gas. Initial cost of installing a butane gas-making plant is far less than the cost today of installing a comparable coal gas plant. It is simpler to operate, being almost entirely automatic. It is quicker in operation; at Whitland 3 hr. working of the butane plant made as much gas as 18 hr. working of the coal gas plant. Furthermore, the use of butane saves coal, itself a most valuable economy. Whitland consumes 538 tons of coal p.a. to supply gas to its 240 consumers; now it will use 70 tons p.a. of liquid butane. Finally, consumers benefit considerably because butane gas has a higher calorific value than coal gas. As to cost, on the basis of the present price of coal and that of liquid butane, it should not exceed that of the old process. The Whitland experiment will be watched carefully by other gas undertakings and it may prove the forerunner of many butane plants which may eventually result in a considerable saving of coal.

At Whitland there are two alternative plants for making the butane/air mixture which constitutes the new 'gas.'

One, a Mallet plant, imported from France, is the plant now primarily used. This plant employs two blowers, one for butane and one for air with a proportioning device to ensure a constant and correct mixture of butane vapour with air. The proportions in the mixture are in the region of three parts of air to one part of butane vapour. In cold weather the storage containers feeding the Mallet plant with the butane vapour have to be specially heated to ensure vaporisation of the liquid. Neat butane is employed as a source of heat for this purpose.

The other plant is a Gasair plant imported from the U.S.A. This operates on the Venturi principle whereby butane vapour under pressure aspirates the required amount of air to give a resultant gas mixture in order to ensure a correct mixture of butane vapour with air. This plant involves the use of a liquid butane vaporiser which is heated by means of neat butane. The Mallet plant is housed in a small building specially erected on the works site. The American plant is a self-contained unit standing in the open. These alternative plants have been installed specially at Whitland to enable full tests to be made of the respective efficiencies and advantages of each method of manufacture. When sufficient experience has been gained a decision will be made as to which of the two alternative forms will be installed at any future undertaking which may be converted to this method of 'gas' supply.

Encouraging careers in engineering

A SUGGESTION for overcoming the shortage of engineers, put forward by an American engineer at a recent meeting of the American Society of Mechanical Engineers, is that engineers themselves should visit schools in their district. They could then talk to groups of prospective students and explain that the growth in opportunities in engineering is not based solely on war and defence conditions, but is also firmly grounded on the natural progress in technology and science. Young people about

Chemical & Process Engineering

As already announced, this will be the new title of the journal beginning with the next issue (April). Here is a selection of articles to be published in future issues:

Chemical Engineering Progress in the Gas Industry

By G. U. Hopton, M.I.Chem.E., M.Inst.Gas.E.

Organic Chemicals from Natural Gas

By R. J. S. Jennings, M.A., A.R.I.C.

Catalysis

By S. L. Martin, M.Sc., F.R.I.C.

The Japanese Alkali Industry

Dust Removal from Boiler Flue Gases

New Factory for Making Fine Chemicals in Bulk

Chemical Engineering Invention—a Monthly Summary of New Patent Claims

to choose their career could be urged, where suitable, to enter the engineering profession. Such a scheme would surely be of value in Britain, where only too often children leaving school are advised by academic-minded teachers to study academic subjects such as the pure sciences, when often the young person's abilities lie in the practical fields offered by engineering and allied professions.

Coal swelling and coke oven damage

THE swelling of coal particles during carbonisation, accompanied by expansion pressures, is accepted as necessary to the production of strong, well-fused coke, and this behaviour is taken into consideration by the designers and builders of coke ovens. However, excessive volumetric expansion accelerates the normal rate of deterioration of oven walls. Today there are shortages of material and labour and high charges for repairs in almost every country, so that it is important to the economic running of coke ovens to reduce and, if possible, prevent damage to oven walls.

There are at least five methods of controlling expansion pressure: (1) Blending of expanding coals with contracting coals; (2) bulk density regulation, by varying the particle size and size distribution, adjustment of moisture content, and addition of oil; (3) addition of inert materials such as anthracite fines; (4) addition of pitch to reduce expansion of low-volatile coals, and to enhance the coking properties of low-grade coals; (5) control of the rate of heating, bearing in mind that decreasing it usually lowers the expansion pressure.

However, before it is possible to apply any of these measures, it is necessary to know within limits the probable expansion behaviour of the coal being carbonised. This knowledge can only be obtained by large-scale testing of different coals with the object of correlating the properties of coal and its expansion behaviour. A programme of research to this end has been drawn up in the United States by the Gas Production Research Committee of the American Gas Association. This programme is set forth in 'Research Bulletin No. 11' published by the Institute of Gas Technology under the title 'Expansion Behaviour of Coal During Carbonisation.' The plan calls for the procurement of samples of types of coal and coal blends with known expansion behaviour from co-operating companies. These samples would be subjected to accepted physical and chemical tests and their internal structures would be measured. It is thought that by starting with groups of coals with pre-

determined expansion behaviour, the presence or absence of any correlation between (1) accepted physical and chemical tests, (2) internal structure, and (3) expansion behaviour and coke quality would be immediately evident. To the extent that useful correlations could be found, they would provide the desired means of predicting the expansion behaviour of coal and coal blends in advance of the slower and more costly oven tests. If these tests did not give satisfactory correlations new tests would be developed, including direct means for measuring the rates of gas evolution as the coal is heated and the permeability of the plastic layer and plastic envelope, or alternatively some means of measuring coal viscosity at high temperatures, using pressure to retard destructive distillation.

It is believed that with the initial tests a reasonable survey of American coals could be completed in one year. The time necessary for developing the second series of tests, however, cannot yet be estimated.

Big methane reserves in Italy

THE utilisation of methane instead of coal as a fuel is proceeding apace in Italy. Already 700 firms are using it as fuel, including Montecatini, Pirelli and Snia Viscosa. Daily consumption is at present running at around 4,000,000 cubic metres, and in 1951 averaged 3,500,000 cubic metres. Daily output is currently about 10,000,000 cubic metres compared with 4,000,000 at the end of 1950. Total production at the end of 1951 amounted to 960,000,000 cubic metres, of which some 80% was used by industry.

Productive capacity of the A.G.I.P. alone—the State organisation which accounts for about 70% of total methane production—had reached 10,000,000 cubic metres per day by the end of 1951, and it is still growing, despite heavy damage inflicted on the wells by the recent floods. With large new pipeline construction schemes on hand consumption is also expected to expand rapidly.

Proven reserves of methane in Italy are estimated at some 40,000 million cubic metres, largely in the provinces of Rovigo and Ferrara. Exploration is being carried out in several areas, and it is thought likely that the figure of 40,000 million cubic metres will be raised substantially by future discoveries.

Even with present resources of methane it seems that Italy has, in addition to a valuable supply of fuel, a source of chemicals of great potentialities. Acetone, methanol, formaldehyde and acetaldehyde are only four of the chemicals obtainable commercially from methane or, as it is also called, natural gas. The fuller possibilities of natural gas as a source of organic chemicals will be described in an article by R. J. S. Jennings, which we shall publish shortly.

A steel industry in Venezuela

VAST deposits of sponge iron, at present estimated at some 1,000 million metric tons, in an area south of the Orinoco River in Venezuela have led to investigations into the possibility of employing the country's plentiful reserves of indigenous natural gas for iron ore reduction. So far, the commercial applications of natural gas in Venezuela have been confined to field operation and on a very limited scale to internal combustion engine propulsion, steam raising, and to providing domestic and industrial fuel gas in the Lake Maracaibo area.

Tests of Venezuelan iron ores in Sweden, where iron ore reduction by a water-gas process is a common practice, and trials with natural gas mixed with low-pressure steam and

re-formed over a catalyst, have shown that the exceptionally high iron content of up to 68% of Venezuelan ore renders it particularly suitable for this type of operation. The ores have remarkably low sulphur and phosphorus contents and their reduction by natural gas is said to yield an almost pure sponge iron, appreciably superior to smelter pig iron.

It is now announced that an agreement for the development of the iron reserves has been signed between the Venezuelan Government and the Orinoco Mining Co. The iron ore, which lies in an area at the confluence of the Orinoco and Caroni rivers, will be extracted by electric shovels, and it will be crushed and stored at a new port, Puerto Ordaz, which is being built. In connection with this, the Orinoco River will be dredged to permit the entry to the port of large vessels. Also planned is a hydroelectric power station on the Caroni River to provide power for the new industry and for other activities such as aluminium smelting.

Canadian asbestos industry prospers

CANADA'S asbestos mines have been working at full capacity for more than ten years and despite rapid expansion of production there still remains a wide gap between supply and demand of the high-grade spinning fibres for which substantial prices are paid. Canada supplies three-quarters of the world's asbestos and last year output constituted a new record, almost 1,000,000 tons, valued at about \$80,000,000. Almost all the asbestos produced is exported.

A large proportion of the expansion in production has come from the increased use of shorts and floats, the fine powders which many years ago were almost unmarketable. Production of shorts now amounts to about 45% of the total output, compared with only 29% in 1940. New applications are continually being found for shorts; already it is used for reinforcing asphalt compounds and floor tiling, for brake linings, moulded plastics, adhesives, paints, insulating cements, welding rods and lubricating greases.

At the moment \$35,000,000 are being invested in new projects and expansions. Canadian Johns-Manville are to invest \$14,000,000 in a new mill at Asbestos, Quebec. The Asbestos Corp'n. are to develop a new ore deposit at Vimy Ridge, Quebec, at a cost of \$10,000,000 and expect to produce 5,000 tons/day of asbestos when the programme is completed in two or three years' time. At St. Andrien, Quebec Province, Dominion Asbestos Mines Ltd. are to build a new asbestos mill with a capacity of 2,200 tons daily (see *INTERNATIONAL CHEMICAL ENGINEERING*, February, p. 94). Moreover, there are no fears of asbestos deposits running out in the near future. Reserves in the Quebec area alone are believed to be sufficient for at least 150 years, while new discoveries are being made in other provinces, particularly British Columbia.

The Indian coking industry

THE Indian coking industry was established about 40 years ago, since when more than 650 coke ovens have been installed. In earlier years the capacity of each oven was about 10 tons; now it is nearly 20 tons. About 3,500,000 tons of coal are carbonised annually.

The development of this industry is a good example of co-operation between Britain and India. With one exception all the coking plants are of British design and have been built and put into operation by British engineers. On the other hand, the operating companies have been financed with Indian capital and the plants built and run

almost entirely by Indians. In addition, the refractories and structural steelwork are of Indian origin.

The first Indian coke oven installation was built in 1908 at Giridih for the East Indian Railway, and since then the coking industry has continued to develop. One of the latest plants has been installed by the Indian Iron & Steel Co. at Hirapur works. This is one of the largest plants in India, carbonising a minimum of 1,600 tons of coal per day. The plant is provided with blending equipment and the layout has been arranged to accommodate two more batteries of the same size which will be erected as demand dictates. The Tata Iron & Steel Co. are also building a new battery of coke ovens and they also have in hand a large programme of rebuilding and modernisation.

Although all the coke produced and most of the gas, too, is used by the iron and steel industry, a proportion of the gas is wasted. This is gas produced by small plants usually situated near collieries and remote from consumer points. This waste could be stopped if it were possible to pipe the gas to a grid for supplying domestic and industrial consumers as in certain European countries. In this connection, attention should be given to the compression and liquefaction of the coke oven gas with the object of removing all constituents except hydrogen. The hydrogen could be used for ammonia synthesis, while the other high calorific value constituents could be fed to the gas grid. Such a system is in operation in France and at the State mines in Holland. Yet another possibility, unfortunately very remote, is the utilisation of waste coke oven gas for the manufacture of chemicals.

Although Indian reserves of coking coals of low ash content are not large, there are good deposits of lower grade coking coal which could be used if coal washeries were installed. The Indian Fuel Research Institute is working on this programme and studies in coal blending have been carried out by the Coal Blending and Coking Research Committee at Jamshedpur.

Unilever

IN an increasingly complex world, simplification is welcome. Furthermore, it is said that simplicity is an attribute of greatness. So here are two good reasons for the decision of the directors of Lever Brothers and Unilever Ltd. to lop three words from this rather unwieldy title and to be known henceforth as Unilever Ltd. in the United Kingdom and Unilever N.V. in Holland. In adopting this short and succinct title the company is going back some 22 years, for in 1930 Margarine Union Ltd. acquired all the ordinary shares of Lever Brothers Ltd. (incorporated in 1894 at Port Sunlight, Cheshire) and changed its name to Unilever Ltd. This latter company was wound up in 1937 and Lever Brothers and Unilever Ltd. was formed. Now the tables are turned. However, the name, Lever Brothers, will not disappear; it is retained in the U.K. in the title of the company which markets the many Lever brands of soap as well as in that of the manufacturing company: Lever Brothers, Port Sunlight, Ltd.

Some people are puzzled at the existence of two companies: Unilever Ltd. in the U.K. and Unilever N.V. in Holland. The explanation is that between them they control the Unilever empire throughout the world. Broadly speaking, the English company controls all Unilever assets in the U.K. and the British Empire; the Dutch company, those on the Continent of Europe and all overseas countries outside the British Empire.

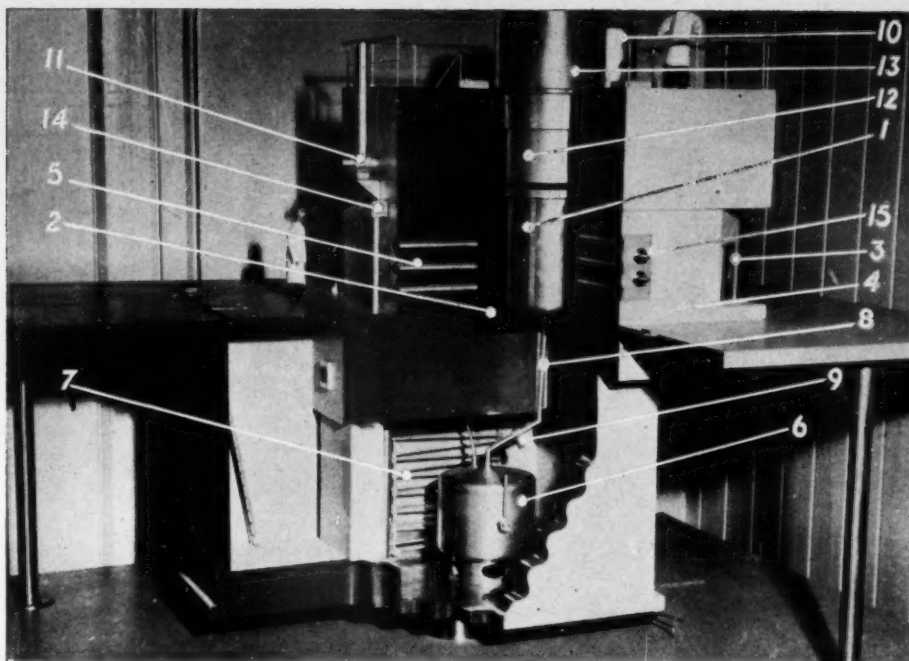


Fig. 1. Cutaway model of the JEEP showing (1) pile tank made of 3.5 mm. aluminium plates, (2) high-purity graphite reflector, 700 mm. thick, (3) thermal column, (4) concrete block covered inside with 1-mm. cadmium plates, (5) three of the isotope channels, i.d. 63 mm., (6) heavy water storage tank, (7) heat exchanger, (8) aluminium tube, i.d. 130 mm., passing from reactor to storage tank, (9) dumping valve, closing aluminium tube, (10) expansion tank for heavy water system, (11) fan drawing air from basement, (12) and (13) water-filled protection tanks, now replaced by 10 concrete discs with total concrete thickness of 1.6 m., (14) four electric motors for moving cadmium plates and (15) two of the ionisation chambers.

Norway's Atomic Pile

By Gunnar Randers

(Director, Joint Establishment for Nuclear Energy Research, Norway)

and Nils Hidle

(Manager, JEEP Department)

Among the small nations, Norway has taken a lead in atomic energy by building and operating an atomic pile capable of producing radioactive isotopes and neutron radiation for research purposes. The pile, known as the JEEP, is a heavy water reactor which operates at a power level of 100 kW. Details of its construction and operation are given in the following authoritative article.

THE applications of radioactive isotopes and neutron radiation in scientific and industrial research have become so numerous and widespread that today a nuclear reactor is a most desirable research instrument in any country with a reasonably advanced technical standard. This is well illustrated in the United States by the number of private firms who wish to build their own reactors. Of course, if it is desired to study the possibilities of using nuclear energy for industrial power, there is even greater need for a reactor.

Up till now many small countries have been able to maintain a general technical standard which is not far behind the bigger and more powerful industrial nations. However, with the advent of atomic energy there appeared to be one important and growing field in which these smaller coun-

tries had no chance of keeping up with developments. With the limited capacity of small nations it is usual for them to have specialists studying developments in other countries and bringing the results back when the development has reached the stage when it can be applied with the means available in the small countries. The developments in atomic energy did not allow this method to be applied. It was not possible for foreign physicists and chemists to study the work with nuclear reactors because of secrecy restrictions. However, it was possible to see enough of the development to understand its importance. Thus the necessity for going ahead as soon as possible with the building of an experimental pile became obvious to the smaller countries several years ago. Even if for no other reason, the study of nuclear

reactors was desirable in order to educate specialists to a standard from which they would be able to assess the scant information on atomic energy received from abroad and thus advise their national authorities on industrial policy.

In most European countries isotopes can today be obtained from Harwell, England. However, the handling and production of isotopes is, in itself, one of the fields in which it is necessary in the long run to have experience based on actual acquaintance with an atomic reactor. Also, some isotopes are difficult to obtain and may have such a short life that they cannot be transported overseas. The only solution then is to have one's own reactor.

The Norwegian pile

For Norway it was natural to plan a

heavy water reactor, since heavy water production was already established. The work was started by an initial grant of 5,000,000 kroner (£250,000) from the Norwegian Defence Department in 1947. A few months later the Norwegian firm, Norsk Hydro, came into the project as a partner on a 50/50 basis. Since the beginning both partners have increased their support for the project as required.

It was decided to construct a heavy water reactor for a power level of 100 kW or somewhat more, and to build at the same time a radioactive laboratory and a physics laboratory on the reactor site. The work was organised by creating a separate, purely civilian Institute for Atomic Energy, under the Ministry of Industry.

One of the serious difficulties was to obtain uranium from the Norwegian sources within a reasonable time and at reasonable cost. This very soon turned out to be a serious problem. When, however, in 1951 an agreement was made between Norway and the Netherlands to run the nuclear energy establishment in Norway on a joint basis, the problem was solved by drawing on the Dutch stock of uranium, which had been stored since 1939. These fortunate circumstances made it possible to put the reactor at Kjeller into operation in July 1951.

The reactor has now been working for about eight months. Most of the running so far has been at low power in order to make the necessary measurements of neutron distribution and radiation level, both inside and outside the reactor.

The cooling system was designed to deal with 100 kW., with the heavy water temperature varying between 50°C. inside the tank and 30°C. in the heat exchanger. Under Norwegian climatic conditions, a temperature well below freezing point prevails during three to five months every year, and the temperature in the heat exchanger can easily fall to below 10°C. It is also possible to increase the circulation rate somewhat. The shielding rather than the heat transfer is expected to be the limiting factor for the power.

During December 1951 the pile was shut down for the construction of a new top shield which will simplify rearrangement of the uranium rods. This modification will make it possible to try test runs to find the maximum power. Until it was put in hand, the reactor had been run up to roughly the designed level for short intervals without cooling.

The design figure for the neutron flux is 3×10^{11} . It is expected that this value will be achieved and probably higher values depending upon the maximum power level.

Design and construction

The pile, known as the JEEP, is a slow-neutron reactor using uranium metal as the fissionable material, heavy water as the moderator and graphite as reflector. It is designed for a power of 100 kW. Power per ton of fissionable material is

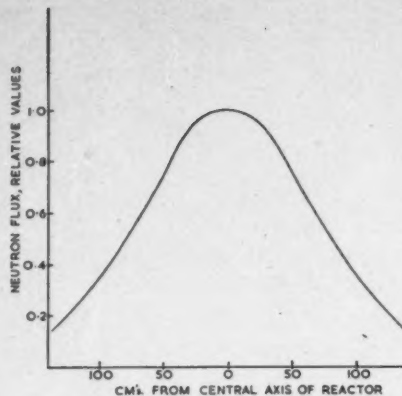


Fig. 2. Radial flux distribution of JEEP.

about 50 kW/ton uranium metal. It is cooled by circulating the heavy water through a heat-exchanger system.

The reactor building has a main hall 20 x 16 m. Below the pile there is a basement room for the heavy water storage tank and for the heat exchanger (heavy water cooled by ordinary water). At the

ends of the hall there are rooms for control and measuring equipment, the heat-exchanger for ordinary water to air, showers and cloakroom with radiation monitors for the operators.

Fig. 1 shows a cutaway model of the JEEP. The pile tank (1) is made of 3.5 mm. aluminium plates. It is 2,000 mm. in diameter and has an overall height of 3,000 mm. The top of the tank is a strong lid which supports the whole tank. The top plate also carries the uranium rods which hang vertically into the heavy water.

The uranium metal is in the form of cylinders, 25.3 mm. in diameter and 282 mm. long. The cylinders are fitted into aluminium tubes of 2-mm. wall thickness to prevent direct contact between uranium and heavy water. Each aluminium tube contains six cylinders, so that the effective length is nearly 1,700 mm. The tubes are mounted two and two on one head, and form a double rod with 12 uranium cylinders. A packing system provides an airtight closure of the hole in the tank top by the head of the uranium rod. There are holes for 76 rods arranged in a square lattice with a centre distance of 180 mm.



Fig. 3. The uranium rods, which are of twin construction with aluminium connecting bridges.



Fig. 4. The reactor tank with cadmium control plates. The opening through the concrete is the thermal column, now filled with graphite blocks.



Fig. 5. The scene in the control room when the reactor was first started up.

Fully loaded with heavy water and uranium rods the reactor tank weighs about 11.5 tons.

Outside the tank there is a reflector (2) of graphite of very high purity. Graphite blocks of standard type measuring $140 \times 140 \times 700$ mm. are used. The thickness of the graphite reflector is 700 mm. The complete reflector contains about 33 tons of graphite.

The thermal column (3), which has a minimum cross section of $1,200 \times 1,200$ mm. at the outer face, is stacked with the same standard graphite blocks as the reflector. The amount of graphite used here is 13 tons.

In the space between the tank wall and the reflector there are four cadmium plates, $300 \times 1,500$ mm. Two of these are used as control plates and the other two as emergency plates. When the plates are to be removed they are lowered into slits in the concrete floor.

To stop the slow neutrons which leak out through the reflector, the inside of the concrete block (4) is covered with 1-mm. cadmium plates. The concrete block itself has a minimum wall thickness of 2 m. and reduces the gamma intensity by a factor of 10^{-8} . In Fig. 1, two tanks (12 and 13) are seen above the reactor tank itself. Instead of these water-filled pro-

tection tanks, ten concrete discs are now installed which give a total concrete thickness of 1.6 m. Each disc has 76 holes corresponding to the position of the uranium rods in the tank. Normally the holes are closed with concrete plugs. To remove a uranium rod from the tank, the plug is taken out and the rod hoisted up into a thick-walled lead tube for shielding.

The reactor is equipped with six 'isotope' channels which run horizontally through the reactor block from one side to another, and cross the reactor tank through the axis. The inner diameter of the tubes (5) is 63 mm. In addition to the thermal column there are two more experimental openings in the block. These are for fast-neutron experiments with 300×300 mm. openings running through the graphite reflector on to the tank wall.

Heavy water system

The heavy water system consists of the reactor tank (1), the storage tank (6), the heat exchanger (7) and the connection tubes and valves. The tanks and tubes are of aluminium and the heat exchanger and valves of stainless steel. All the connections between the steel and aluminium are electrically insulated to prevent corrosion. For cooling, the water is taken from the top of the reactor tank, pumped through the inner tubes of the heat exchanger, which consists of two concentric tubes, and back to the bottom of the tank. An aluminium tube with inner diameter of 130 mm. (8) leads from the bottom of the reactor tank to the top of the storage tank. This tube is normally closed by a 'dumping valve' (9). When the valve is opened, the reactor tank empties completely in 45 sec. The circulation pump for the system can run at two speeds, 2 or 4 l./sec. Because the heavy water system is completely closed, an expansion tank (10) is connected to the system to take up small pressure variations.

In the heat exchanger the heavy water is cooled by ordinary water circulating through the outer concentric tube. This water is then pumped through an air cooler and back to the heat exchanger. The circulation pump for this system gives a flow of 1, 8 or 3 l./sec.

A fan (11) mounted on the reactor block draws air from the basement up along the wall of the reactor tank, through a horizontal channel in the block and blows it out through a stack. The air flow provides sufficient cooling for 5 to 6 kW. At the same time the fan creates a slight under-pressure inside the block so that there is small chance of radioactive dust escaping into the hall.

Operation of the pile

The pile is operated from the control room. The cadmium plates are moved by four electric motors (14), arranged on the walls of the reactor block. The plates hang by wires with counterweights attached. The emergency plates are held

by magnetic clutches. If the emergency plates are right down in the concrete floor when the clutch current is broken, the plates are lifted into their upper position by the counterweights in less than 1 sec.

The positions of the plates are indicated by servo-transmitters mounted in the motor gear boxes (14). In the control room, receivers indicate the position on the control desk. For the control plates the indications are given on two dials, one reading in mm. and one in cm. For the emergency plates there are only cm. indications. The position of the control plates can be regulated and indicated with an accuracy of ± 1 mm.

In the reactor block there are six ionisation chambers (15). They are of the same types as used in the British GLEEP reactor,* 5 l. volume, filled with boron trifluoride gas at 20.7 cm. Hg pressure. The geometrical position of the chambers can be changed, and three sensitivities can be chosen at the preamplifier so that the chambers cover a range in pile power level from 1 W up to 100 kW. The preamplifiers are mounted on the chambers, while the main d.c. amplifiers are in the control room.

One of the chambers is used as chief level indicator. Three of the others duplicate this chief indicator. The output from the d.c. amplifiers of these three chambers can operate a trip circuit when the power level exceeds a pre-set value. These chambers are then used for auto-

matic shut-off. The trip circuit of two of them will break the clutch current to the emergency plates so that they fall in and shut off the pile. Simultaneously the control plates will start moving in at normal speed. If the level continues to rise due to some fault in the two circuits, the third-chamber will not only send the four cadmium plates up along the tank wall, but also open the dumping valve and drop the heavy water from the reactor tank. The fifth chamber is used for automatic control of the power level. The automatic control operates on the absolute change in power level. The last chamber in the block is supplied by battery voltage and works directly on a galvanometer. The power level is continuously recorded by means of the output current from the d.c. amplifiers in the control room.

The pumps and valves for regulating the water level in the pile can be operated from the control room. The temperature at different points in the cooling system is continuously recorded, and the water flow in the two water systems is integrated over time, which makes it easy to calculate the power level. Geiger-Müller counters check possible radioactivity in the heavy water and in the air blown out of the stack.

The flux

Not many results of the measurements on the JEEP can be given at this time, because the pile is not yet in its final condition. The radial flux distribution as measured in an isotope tube in the middle of the tank is shown in Fig. 2.

a low neutron flux and many can be done equally well in slightly lower neutron fluxes available near the outside of the pile.

The Canadian pile was designed and constructed to be an instrument of research and, like all instruments, it has specific capabilities and specific limitations. Within these limitations, its radiation facilities are offered to approved projects not only throughout Canada, but to other countries as well. Their use is subject only to the restrictions imposed by practicability, cost and the security of the plant.

A catalogue giving all details on radio-active isotopes available and conditions for special irradiations can be obtained from Eldorado Mining & Refining (1944) Ltd., Ottawa, who handle sales of isotopes on behalf of the National Research Council's atomic energy project.

Recent publications

Organic chemicals. A new edition of 'Bisol Organic Chemicals,' published by British Industrial Solvents Ltd., gives up-to-date technical information on the widening range of solvents, plasticisers and other products supplied by this firm. British Standard specifications, where available, are included for comparison with those for Bisol products. An appendix gives physical constants, dilution ratios, miscibilities and compatibilities of the products described. Other appendices deal with the testing of solvents, volumetric determinations and conversion tables. There is also an index of chemical formulae. The book is extremely well produced, consisting of 246 pages bound in stiff cloth covers.

Industrial vacuum cleaners. Multi-stage turbo-exhauster type vacuum cleaners are widely used in industry. Sturtevant Engineering Ltd. catalogue their range of cleaners, ranging from $\frac{1}{2}$ B.H.P. to 90 B.H.P. in publication 5006. Electric power is normally used, or arrangements can be made for driving by petrol or diesel engine. A variety of cleaning tools is provided. An example of the many uses of these cleaners in chemical works is the cleaning of mixing machines.

Nickel-chromium alloys. A revised edition of a booklet describing the *Nimonic* series of alloys and their application to gas turbine design has now been published by the Mond Nickel Co. Ltd. and includes the latest information on the subject.

Arc welding electrode. A 28-page booklet containing full technical information on the Philips '48' arc welding electrode, together with a great number of illustrations, graphs, photographs and tables, has been issued by Philips Electrical Ltd. The text deals with the theoretical as well as the application aspects and includes items such as the functions of the coating of the type '48'; resistance to hot cracking; welding procedure; mechanical properties; mild steel welding with the type '48'; high-speed welding, etc.

The Canadian NRX Atomic Pile

FACILITIES provided by the Canadian NRX pile for the production of radioactive isotopes and for the neutron bombardment of special materials for experimental work are described by Mr. F. W. Gilbert, assistant manager in charge of operations at Chalk River, in *Nucleonics*. The information given should help experimenters to understand better, not only the exceptional capabilities of the NRX pile, but also why it is not always possible, or desirable, to irradiate substances with the highest neutron flux available.

The capabilities of the NRX pile are well exemplified by its production of the radioactive cobalt required for the 'cobalt bomb'—the latest and most powerful therapy unit for cancer treatment—the first of which was installed last year at Saskatoon, and the second at the Victoria Hospital, London, Ontario. The NRX pile is the only one in the world known to have been capable of producing sufficiently powerful radioactive cobalt.

In producing most radioactive isotopes, the greater the neutron flux with which a given quantity of the parent substance is bombarded, the greater is the strength of the radioactivity produced, or the shorter

is the time required to produce a given strength. In the NRX pile, the neutron flux is high because the volume of its reacting core is small in relation to its power. It is in this concentrated reacting core that the neutron flux is highest.

The smallness of the core, in itself, imposes some limitation on the use that can be made of the pile for isotope production and bombardment with high fluxes, because most of the space is taken up with materials necessary for operating the pile, but further than this, the highest flux exists only in a small space near the centre of the core. Since this small space has the highest neutron flux available anywhere in the world, it is in very great demand.

For high flux bombardments, the smallness of the space available is not the only limitation. Neutrons are used up in the process of making radioactive isotopes and, if too many are removed in this way, the pile will stop operating, because it depends on the neutrons to keep the chain reaction going. Unfortunately, it is permissible to remove far fewer neutrons from the centre of the pile, where the neutron flux is highest, than from other parts. However, the production of some isotopes requires

EVAPORATION

Installations for salt, sugar and fruit juices; low temperature evaporation; special units; theoretical advances

By J. M. Coulson, M.A., Ph.D.

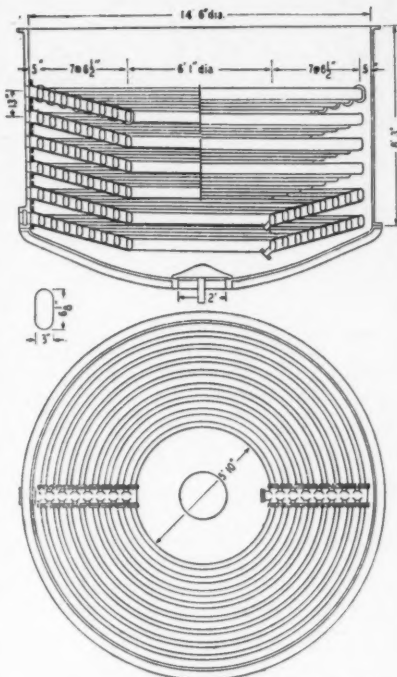
(Department of Chemical Engineering, Imperial College, London University)

DURING the past year the sugar, salt and paper industries have provided further evidence of the importance of evaporation in their processes. With sugar one of the main problems is the handling of the very thick magma in the final vacuum pans, whilst the paper industry is worried by the problem of scale in the handling of waste liquors. The increasing production of concentrated citrus juices such as orange has resulted in considerable interest in low-temperature evaporation, and a number of articles in this field are discussed below. The attraction of the falling film unit for this type of work was referred to in the previous review,¹ and it will be seen that this is almost the standard unit for low-temperature work with fruit juices. The development of an evaporation unit involves the practical application of our present ideas on heat transfer to boiling liquids, together with a realisation of what happens to the feed liquor during concentration. This latter point is of particular importance in the food industries where freedom from break-up of the essences or vitamins is essential, and hygienic plant must be designed. It is also important with those materials which have an inverse solubility curve, or which present special difficulties in crystallisation. Together with these physical factors the limitation of engineering construction must be remembered. Finally, as is brought out later,² the choice of unit will eventually rest not only on the economics of the evaporator itself but also on its suitability for the available power system of the factory.

This review is divided into sections covering the performance of existing installations in the sugar, salt and fruit juice industries, together with reference to recent theoretical and laboratory work; reference is also made to auxiliaries such as condensers, instrumentation and the problem of materials of construction.

Performance of installations

(1) **Sugar.** A broad survey of the refining of sugar at the Imperial Sugar Co.'s plant in Texas is given by Shearon, *et al.*³ This includes the whole of the



[Diagram: International Sugar Journal
Venton's arrangement for a coil pan of
8,500 gal. capacity.]

refining stages, which are illustrated with simplified flow diagrams. The first liquor from the char filters has 55 lb. of water per 100 lb. of sucrose, and to reach saturation level some 25 lb. of water have to be evaporated. The first or pre-evaporator in which single-pass working is used is a long-tube type (18-ft. tubes with a 7×7 ft. vapour head). It is of interest to note that these have superseded the old horizontal film type units which are now used for other liquors. These had 331 tubes, 3 in. o.d. by 7 ft. long, giving a tube area of 1,819 sq. ft., and a plate area of 297 sq. ft. They are capable of handling some 12,000 gal./hr. of liquor, increasing the density from 64° to about 70° Brix. The final vacuum pan is a vertical calandria unit with a low vapour head. The tubes are 4 in. o.d. and 4.25 ft. high, set in the

steam space (10 ft. o.d.) at the bottom of the pan. Above the tube sheet is a 12-ft. diameter disengaging space to which the vacuum line is connected. These dish-bottomed calandria pans are preferred to the coil type because of easier maintenance. In control of the pans, instrumentation of the vacuum is the main feature, as instanced by Webre.⁴ Thus the seeding, growth and strike periods are all controlled by suitable adjustment of the vacuum. With the pans used, some 80,000 lb. of dry granulated sugar are obtained at each strike. Details of the equipment are given for all the various stages of treatment.

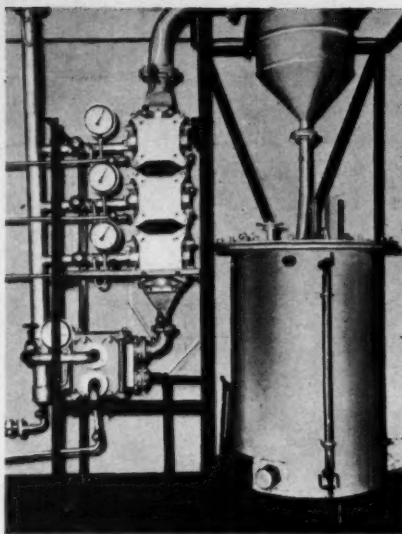
Venton⁵ gives further details of the flattened circular coils as used in the Queensland pans. These coils are formed by rolling a 5-in. copper tube to give an oval of 6×3 in., with flattened long sides. He gives details of the design for an 8,500-gal. pan (as shown here), with a heating surface of 1.44 per unit volume. Centre well size, height and spacing of the coils are discussed. He considers that the coil-type pan with high surface per unit volume will perform as well as the calandria type with internal agitator, particularly with very high crystal contents. He gives figures to show that the coil type will be cheaper. The lower ratio of height to diameter gives easier circulation and maximum heating surface. This question of coil and calandria pans has long been a subject for discussion and, from the above papers, it would seem that the matter is not yet finally settled.

(2) **Salt.** Lee⁶ gives an account of the vacuum evaporator and the grainer processes for the refining of salt at Morton's new refinery in the United States. In this paper particular attention is given to the materials of construction and the methods of handling at the various stages. Thus the inside lining of the long pans used in the grainer process are protected with Neoprene rubber and the internal mechanism is of stainless steel or steel protected with phenolic coating. A monel scraper conveyor is used in the bottom of the grainer to rake the crystals that fall to the bottom, and discharge them to a screw conveyor. The triple-effect evaporator

used in the vacuum process has cast-iron bodies with steel tube sheets and copper tubes. Circulation is increased with monel propellers on stainless-steel shafts. Formation of salt scale necessitates periodic boiling with water every 48 hr. The salt slurry is withdrawn from each effect through a salt leg. The brine is fed to the bottom of the leg, so that the slurry leaving is washed by the feed, the impurities being thus washed back into the pan till cleaning is effected. Monel pipelines and 4-in. rubber hose are considered more effective with hot brine than stainless steel. *Ni-Resist* is used for hot brine pumps, whilst the screw conveyors are coated with phenolic resin. These various materials used for construction serve to emphasise the difficulty in selecting the most suitable material and bring out the fact that there is no one material suitable for handling the hot concentrated brines.

A recent installation in the U.K. (see p. 130) evaporates brine containing about 300 g./litre to some 25% solids in brine liquor.⁷ The brine is first purified to remove the calcium and magnesium in solution before evaporation in a triple effect vertical evaporator. The units, which are fed in parallel, are 11 ft. in diameter and are of cast iron construction with a bottom slurry draw off leg. Part of the brine feed is introduced at the base of this leg to wash the crystals free from mother liquor and the remainder is introduced immediately below the calandria. The latter consists of a tube bundle of 1,398 copper tubes (6 ft. 5 in. long by 2 in. o.d.), with a central downtake of 3 ft. diameter. This provides a surface area of 3,300 sq. ft. The natural circulation is augmented by an internal agitator driven from the base, and heat transfer coefficients of 550, 350 and 250 B.Th.U./hr./sq. ft./°F. are obtained for the various effects. The slurry drawn from the units is pumped to rotary drum filters, and the filtrate is returned to the evaporators.

(3) Citrus juices and low temperature evaporation. The production of frozen fruit juices, especially orange and apple, has become of increasing importance and has involved a good deal of work on the design of low temperature evaporators. This is an interesting field where hygienic conditions are vital and the maximum permitted temperature for evaporation is low (55 to 80°F.). Walker, Nimmon and Patterson,⁸ discuss the best temperature range for the concentration of apple juice, and show that concentration in a falling film evaporator at temperatures up to 130°F. can be effected without detriment to the flavour, but that temperatures of 145°F. give significant alteration to the flavour. They suggest separation of the volatile constituents by partial vaporisation in a short tubular evaporator with a transit time of about 2 sec. The vapours are concentrated by fractionation to give the essences and the residual liquors from the first partial vaporisation are concentrated by



[Photo: Powell Duffryn Carbon Products Ltd.]

A new development in the climbing film and forced circulation types of evaporator for corrosive liquids is this evaporator constructed of graphite. It permits evaporation of acids with high-pressure steam, thus obtaining very high overall heat transfer coefficients. Overall dimensions are 12 in. x 12 in. x 36 in. high. The evaporation surface is 30 sq. ft. and the unit can evaporate 130 lb./hr. of water using steam at 75 p.s.i. The evaporator unit itself is similar in principle to the Powell Duffryn graphite cubic heat exchanger which has, during the past few years, proved so successful for all types of heat exchange applications involving corrosive fluids. The evaporator is composed of a number of graphite blocks connected together so that a series of parallel holes are formed which run vertically through the graphite and act as a group of graphite tubes through which the acid to be evaporated flows. In the same graphite blocks there is a number of holes which run horizontally and interlaced between the vertical holes. Through these holes the steam for evaporation is led and the condensation removed by gravity at various points. The graphite blocks are held under heavy compression by cast-iron headers. Suitable cast-iron headers are provided for the steam supply and carbon-lined headers for the acid inlet and outlet connections. Due to the excellent corrosion resistance of 'Delanium' graphite, it is possible to evaporate most acids at atmospheric pressure, but if required vacuum or multiple effect operation may be obtained as with normal evaporation plant. Due to the use of high-steam pressure (up to 150 p.s.i.) and the very high thermal properties of graphite, overall heat transfer coefficients of 500 to 600 B.Th.U./hr./°F./sq. ft. are obtained. In this photograph a preheater is shown to the left of the evaporator unit and to the right is a carbon-lined separation vessel.

evaporation. Various alternative procedures are discussed.

Further details of the partial vaporisation system involving the injection of live steam are given by Brown *et al.*⁹ The preheated feed goes to a steam injection heater where very rapid heating is achieved by the introduction of live clean steam. The hot fluid leaving the injection heater has from 1 to 3% by weight of vapour and enters the horizontal tubular evaporator at

high velocity. The overall transfer coefficients obtained in the evaporator are from 500 to 600 B.Th.U./hr./sq. ft./°F.

Schwartz² gives an interesting and instructive comparison of the various systems for low temperature evaporation. The three distinct types in general use are the single effect single pass, single effect with recirculation, and multi-effect with recirculation. For each of these types the water vapour pumping system may be by steam recompression, or in the form of a second heat cycle using a separate heat transfer medium. In terms of low capital and operating costs the multiple effect units are most attractive, followed by single effect recirculating types. The single effect single pass system has the advantage that the transit time in the unit is very short. Thus a single pass system with 14 towers only gave a transit time of 6 min. and a maximum product temperature not above 60°F. A double effect recirculating unit had a 30 min. transit time with temperatures of 75°F. in the first effect and 57°F. in the second.

In considering the selection of evaporators from the purchaser's aspect, the initial and operating costs are naturally considered, but Schwartz goes on to urge the importance of hold up, insurance coverage, waste disposal, ease of operation including any special features in the starting up or shutting down. He cites the figures in Table 1 as a comparison between a double effect steam recompression system and a similar unit with an ammonia refrigeration cycle, the capacity being 10,000 lb./hr. of evaporation.

The figures were taken from various manufacturers' bids and the 320 kW (c) includes a 400 h.p. Compressor. From this table Schwartz shows that the utilities for the refrigeration system will be appreciably less than for the steam recompression system, but that the installed cost of the refrigeration unit will be appreciably higher. A flow diagram is given of a double effect unit with an evaporating capacity of 6,000 lb./hr. using an ammonia refrigeration cycle. From this (reproduced on p. 129) it is seen that the flow is backward feed, the first effect being heated by warm water which has picked up heat from the ammonia condenser. The water vapour is condensed in an inclined tube unit with the ammonia inside the tubes. The first effect has a surface of 1,750 sq. ft., and the second 2,100 sq. ft., giving overall transfer co-efficients of 75 and 117 B.Th.U./hr./sq. ft./°F.

An excellent account of the development of chemical engineering in the frozen food industry is given by Praschan,¹⁰ who traces in particular the development of the evaporating systems. Diagrams are given to show the arrangements for two stage backward feed systems with thermocompression operating with a liquor temperature of 58°F. in the second and at 80°F. in the first effect. Additional diagrams are given for a three pass single effect system

chambers. After a period of running the chambers are switched from steam to liquor and *vice versa*. The fouled chambers are then cleaned by the steam and scaling is very substantially reduced.

McCullough¹³ discusses the concentration of radioactive waste liquors. This involves a totally enclosed unit with a batch evaporator of the forced circulation type, taking a charge of some 10,000 gal. The vapours are passed to a 12-ft. diameter entrainment separator and four bubble plate trays to ensure complete elimination of entrained liquor in the vapour. The concentrated liquor is passed to a totally enclosed double drum drier.

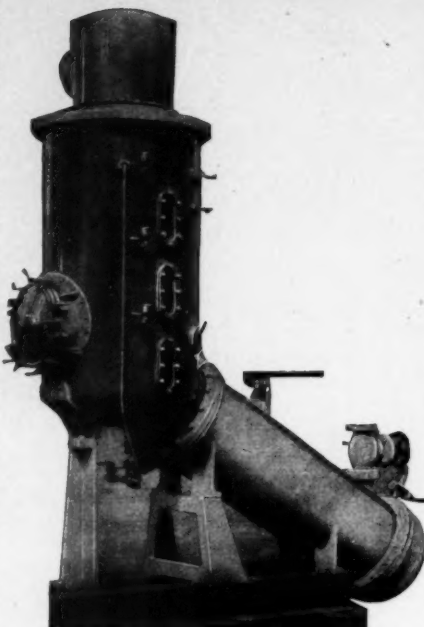
In several papers presented at an Ion Exchange Symposium¹⁴ suggestions are made for the use of ion exchange techniques in the concentration processes which may prove alternatives to direct evaporation; thus glycerol may be extracted and concentrated by these ion exchange processes.

Theoretical and laboratory studies

Papers of interest to designers of evaporators were presented at the recent London Conference on heat transfer of the Institution of Mechanical Engineers and the American Society for Mechanical Engineers.¹⁵

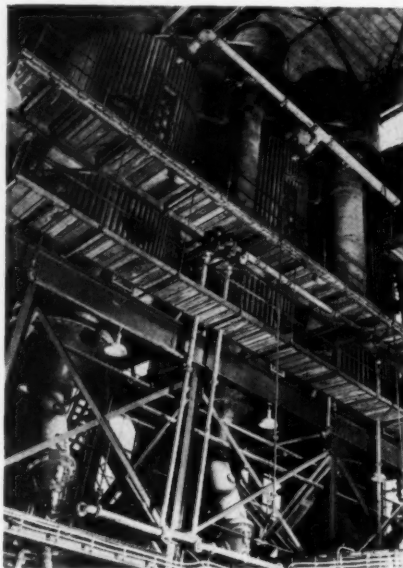
Brown¹⁵ describes experiments on the heat transfer by condensation of steam in a spray of water drops. He gives theoretical considerations based on the conduction of heat into the drop on the assumption that surface resistance to transfer is negligible. Experimental work is described in which the steam saturation temperature, water feed, mean drop size, height of fall, and presence of air are investigated in a small chamber. The actual heat transfer coefficients are shown to be very high, figures of 4,800 B.Th.U./hr./sq.ft./°F. being found. Hampson¹⁶ discusses the condensation of steam on a metal surface, and Yoder and Dodge¹⁶ give experimental data for boiling *Freon* 112 in an electrically heated vertical evaporator. Colburn and Carpenter¹⁶ discuss the effect of vapour velocity on the condensation of vapours inside tubes using steam and several organic vapours. Using a tube 0.454 in. i.d. and 8 ft. long with vapour velocities up to 500 ft./sec., they were able to show that the higher velocities gave turbulence in the condensate film and higher coefficients.

There have been few reported measurements on the actual rate of circulation in natural circulation evaporators. Bosworth and Dulay¹⁶ report experiments on ten calandria and coil type pans used in the sugar industry. They used a hot wire anemometer, the heat input to maintain the wire at a certain temperature above the fluid being taken as a measure of the rate of circulation. The average values found did not differ much between the pans, figures of 10 cm/sec. being found for *A massecoites* falling to 8, 4 and 2 for the heavier



[Photo: Bennett Sons and Shears Ltd.]

Rapid circulating evaporator of the inclined tube type for concentrating delicate liquids and chemical preparations under high vacuum. Rapid circulation is induced by allowing the vapours to pass freely to the condenser; the liquor, when flowing up the inclined evaporator tubes, is not retarded in any way, there being no right-angled corners to baffle the natural flow. Consequently, as the concentrated liquor drops downwards into the separator, the vapour instantaneously escapes freely from the liquor. The concentrated liquor returns to the evaporating tubes by means of the circulating tubes at the bottom. These tubes, being shielded in the inside of the calandria, are kept at a lower temperature than the liquor in the evaporating tubes, thus increasing the natural circulation.



[Photo: Industrial Chemist and Murgatroyd's] Recent installation in the U.K. for the evaporation of brine. It includes a triple-effect vertical evaporator. (See p. 128.)

loads. There is a drop in circulation as each load is concentrated but this is not proportional to the loss in fluidity. Considerable variations in local velocities are reported. For the calandria pans, if the velocity of the upstream is greater than that down in the central well, then any given particle will spend longer in the well than in the outer zone. The implication of this in connection with crystallisation is discussed.

Walker and Patterson¹⁷ give details of construction of a small glass falling film unit used for testing the concentration of fruit juices. This paper is interesting and complementary to the papers previously mentioned, in which the industrial figures were given. Their unit was essentially a 150 cm. tube of 75 mm. i.d. in a jacket of 85 mm. i.d. From the glass vapour separator the vapour passes to a condenser and any uncondensed gases to a series of cold traps, ice, alcohol dry ice, and liquid nitrogen. These traps pick up any volatile essences and enable the mixture to be reconstituted from the concentrated liquor and vapour. Recirculation of the non-vaporised liquor from the separator was effected by a stainless steel pump.

When used as a batch unit the initial rate of evaporation was 12 lb./hr. of water over the range 0.23 to 3.7 psig., using a jacket temperature 60°F. greater than the evaporating temperature. The unit enables the influence of evaporating temperature to be found but it is not easy to translate the rate of evaporation to industrial conditions with, say, a stainless steel tube, since the actual wall temperature is not known.

Details of a very small climbing film evaporator for laboratory use are given by Birch and Nathan.¹⁸ This can be constructed from standard glass apparatus; thus the evaporator is made from a 9 or 12 in. internal single coil condenser.

For the calculation of temperatures, areas and economies in the design of multiple effect units the method of Storrow¹⁹ is probably the most convenient, but care must be taken when substantial preheating of the feed or vapour withdrawal takes place.

The problems of automatic control of evaporators are always arising and Slater and Fehlberg²⁰ discuss this question for the low temperature evaporators. They give details for controlling a three stage thermocompression unit with a capacity of 1,174 gal./hr. at 42° Brix. A product density controller retards or speeds evaporation according to deviation from density of product, and a product level controller regulates the feed. These two instruments actually interact so that if the concentration decreases the density controller slows the product removal and the liquid level controller reduces the feed. A vacuum controller is desirable and a product temperature controller may help in keeping the system at the best temperature level. De-

(Concluded on page 136)

Utilisation of Sulphite Waste Liquors

Enormous tonnages of waste liquors arise in the production of paper pulp by the sulphite process. These liquors, which contain appreciable quantities of lignin, can be used to make many useful chemicals and chemical products, ranging from alcohol to fodder yeast. However, most of the products available from these liquors can already be produced from other sources in some cases in much better quality, in others more cheaply. Thus, serious economic barriers prevent the proper use of these raw materials. Nevertheless, as shown in this article,* attempts are being made to remove these obstacles, not only because these liquors are useful industrially, but also because their disposal is becoming increasingly expensive, as more stringent anti-pollution laws are passed in different countries.

THE paper industry is faced with the problem of utilising and disposing of many waste products when pulp for paper-making is manufactured by chemical treatment. Among the various unwanted substances which have to be removed from the cellulose in the wood is lignin. To produce 100 tons of pulp (the daily output of an average chemical pulp mill), about 200 tons of wood, barked and calculated as air-dry, are required. Of the unwanted substances dissolved away, lignin accounts for 60 tons. Therefore, in a 300-day working year 18,000 tons of lignin are produced. World production of chemical wood pulp is about 20,000,000 tons annually; on this basis of calculation, the world's paper pulp industry separates 12,000,000 tons of lignin annually from wood; in addition, perhaps nearly half of that amount is separated in sugar compounds.

These by-products constitute a challenge to the paper industry; with a few notable exceptions they are entirely wasted. But very considerable efforts are being made to convert them to useful purposes, and much time and money has been spent upon their investigation. In the last 30 years or so a great deal has been learned about lignin, although there is still much to discover. The method of its formation in the growing plant, its chemical structure, and its behaviour under many conditions have yet to be conclusively established. So far, the paper industry has found it possible to utilise only a very small proportion of its lignin and other pulping wastes.

The lignin and other waste products can be used directly as fuel, or modified to produce alcohol, fodder yeast, plastics, fertilisers, binding agents, powerful dispersing agents, tanning agents, and a series of valuable chemicals like vanillin, butyric acid and oxalic acid. All of these products are in demand by industry; but nearly all of the pulping wastes produced by paper mills are poured into rivers and the sea as effluent—often to the detriment of fisheries. The reasons are primarily economic; but to understand them it is necessary to study in more detail the properties and known uses of pulping waste liquors.

Sulphite process liquors

To make the examination more specific, the liquors produced by the sulphite pro-

cess alone will be considered because, whereas in the other two major chemical processes (the soda and sulphate processes) cooking reagents can be recovered by evaporation and subsequent burning of the liquors, with utilisation of the heat value of the lignin and sugar as an incidental advantage, this is not normally possible with sulphite liquors. However, the pulping by-products in the waste liquors from these two processes have potential uses other than as fuel, similar to those from the sulphite process. In the sulphite process wood chips are cooked under pressure with a chemical mixture usually of calcium and sulphurous acid. The waste liquor contains the lignin in a soluble state in the form of calcium lignosulphonate, and sugar compounds from the decomposition of the unwanted cellulose material in the wood.

Fuel

The most straightforward, but probably least satisfactory, way of using these by-products is as fuel under the boilers of the mill which produces the pulp. This use is comparable to the burning as fuel of untreated 'immature' coal—in which case most of the valuable chemical distillates, tars, oils and so forth disappear in the combustion process. The lignin and sugar compounds in sulphite liquor are composed of carbon, hydrogen and oxygen, molecularly linked in various ways. These can be burnt to provide heat and power, although not, naturally, in the dilute solution of nine parts water to one of lignin and sugar compounds in which they first appear. The water must be evaporated until the residue contains 50% of solid matter. Such a fuel does not have the calorific value of a good coal (only 8,000 B.Th.U./lb. dry compared with 13,000 B.Th.U./lb.), but it can supplement the coal, and, depending on its cost, reduce fuel bills.

Two difficulties are encountered in its use as fuel, however. In evaporating the dilute liquor to the 50% concentration, scale in quantities, which proves hard to remove, is formed in the evaporators, and the ash content of the fuel itself is so high as to require specially designed furnaces. Until both evaporators and furnaces are better designed for the use of liquor in this way as a fuel, the disposal of large quantities of it cannot be expected. One great advantage of burning the waste on the spot is that it purifies the mill's effluent.

Alcohol

The chemical products from the waste liquors must, however, be considered. First among these is alcohol, one of the most important chemicals used today by industry. Lignin itself does not ferment to alcohol, but the sugar compounds accompanying it in sulphite waste liquors can be fermented with yeast to produce ethyl alcohol. Commercial fermentation processes have been fully pioneered, of course, and, in Scandinavia and Germany in particular, plants for making alcohol in this way have been in operation for many years. Two plants in Canada and one in the U.S. have recently been constructed for producing sulphite alcohol.

In this process the neutralised liquor is led into large fermenting vats where yeast is added. After the required fermenting time the alcohol is distilled away from the rest of the liquor and purified. In this way, a part of the solids in the waste liquor, about one-sixth, is converted to alcohol.

The importance of alcohol to chemical industry is particularly great in countries which have difficulties with coal or petroleum supplies, since it is an alternative starting material for the manufacturers of many chemicals. Sweden, for whom crude oil is a very expensive import, has made sulphite liquor alcohol the basis of much of its chemical industry even in peacetime. Two world wars have given a fillip to this process in other parts of the world, but waste sulphite liquor finds it hard to compete in normal times against plentiful supplies of cheap alcohol from other sources.

Fodder yeast

Another fermentation process also makes possible the production of fodder yeast. By the agency of an initial small quantity of yeast, proper nutrients for growth and plenty of air, the sugars in the liquor readily produce an edible yeast, suitable for feeding to cattle and poultry. It is cheap. This use of sulphite waste was initiated by Germany during the First World War, and since then manufacture has spread in a small way to North-East Europe. Moreover, interest has recently quickened in America. In Wisconsin the process has been studied on a pilot plant to obtain data about the probable economics of the process and the food value of fodder yeast for different animals. It appears from these experiments that, while not

*Reprinted from *The Bowater Papers*, (2), 1951, published by The Bowater Paper Corporation Ltd.

entirely suitable for all animals, it is very satisfactory for a large number of them.

Other fermentation processes can also produce butyric and lactic acids from sulphite liquors, but these have not been exploited on a large scale as yet.

Plastics

Some progress has also been made in developing plastics from lignin. During the recent war it was an important source of plastics raw material in both Germany and America. The conditions were, of course, somewhat artificial and at the end of the war the demand for plastics from this source was considerably reduced. The problem was one of quality rather than of cost. Although the lignin plastics were cheaper than plastics from other materials, the latter possessed advantages which offset their extra cost. However, some cheap plastics are still being produced from lignin and a number of firms are trying to improve their quality.

Dispersing agents

Lignin and its derivatives have been found to be excellent dispersing agents, useful for dispersing uniformly a large number of suspensions of solids in liquids. In other words, they possess good colloidal properties. In a suspension, the individual particles very often tend to stick together in clusters which hamper the flow of a liquid. When lignin derivatives are added to the suspensions, the clusters are broken up and the individual particles dispersed, allowing freer flow.

For example, a 50/50 mixture of clay and water is normally a solid, dough-like mass. But by adding a very small amount of calcium lignosulphonate the suspension flows readily with a consistency almost of milk. This treatment has two advantages. Either the resistance to flow of a mixture can be reduced, thus lowering the power consumption of the pumps circulating it, or the solids content of a thick slurry can be increased and still enable it to flow through the system.

Because of these properties, lignin compounds can be used in oil wells where a mud is circulated in the borehole to carry away rock from the drilling tool to the top of the well. They can also be used in cement. Here, a more concentrated slurry can be worked, so reducing the ratio of water to cement in the mix: this means that greater strength can be achieved in the concrete and corrosion resistance increased. Again, by using lignin sulphonates to disperse clays, shapes can be moulded and worked with a considerably lower water content, thus making ceramic products stronger and reducing wastage due to handling and cracking in the driers. They will also disperse clays more uniformly in whiteware, and pigments in glazes. Small amounts are useful in grinding where they prevent the formation of flocs or agglomerates, so greatly increasing the grinding efficiency.

Lignin sulphonates are also useful dis-

persants for carbon black, dyestuffs, cleaning compounds and emulsions; and in any field where dispersive action is necessary, lignin compounds of one type or another are generally as good as, and in some cases better than, other agents.

Adhesives

The fibres in growing plants are most probably held together mainly by the adhesive properties of the lignin. It is understandable then that these adhesive properties should be utilised in binding other materials together. Lignin derivatives have been found useful as adhesive for linoleum, plywood compositions and building board.

Road surface binder

Other uses have been found for this property of lignin. In Scandinavia, America and Canada concentrated sulphite waste liquor is being used on some classes of roads as a surface binder and as a dust-laying agent. Considerable quantities have been used up in this way. This bonding is even more pronounced at high temperatures. Consequently lignin derivatives are added to foundry cores, moulds for casting metals, refractory bricks and coal briquettes (where they help to preserve the shape of the mould), and to powdered fibrous material, sand, and gravel for the manufacture of artificial stone.

Tanning materials

For many years lignin sulphonic acids have been used as tanning materials in Europe and America. Although they lack the quality of other natural tannins, such as quebracho, the recent shortage of this latter material, particularly in America, brought these lignin compounds into further use and a great deal is being done to try to improve them as tanning agents.

Fertiliser

The close relationship of lignin to humus—that important constituent of the soil which is formed by the decay of plant substances including lignin—and the presence in sulphite waste liquor of such chemical elements as calcium, sodium, potassium, phosphorus, and sulphur, suggest that it should be an excellent fertiliser. A patent was first granted for the preparation of manure from waste sulphite liquor in England in 1886, but since then there has been a great deal of controversy as to the effect of the liquor on the soil. Recently, however, it has been shown that the chemicals in the liquor can have a beneficial effect on certain crops, and these reports are encouraging. If this use of lignin could be established a very large amount of it could be consumed.

Organics

Lignin derivatives are very reactive chemically, and it is not surprising that a number of organic chemicals have been prepared from them. The most interesting

is vanillin. If lignin sulphonates are treated with caustic soda, vanillin is produced. After many years of pioneering, one well-known mill in the U.S. has been operating this process commercially for some time, producing the bulk of the vanillin required for flavouring in North America; it could, without much difficulty, supply the world's total requirements. There are other less well-known derivatives manufactured, such as vanillic esters, but these are limited mainly to medical and biochemical applications, chiefly as food preservatives.

Miscellaneous

There are numerous other applications of sulphite waste liquor derivatives, and several hundreds of patents describing them, but these have only minor industrial significance. A few other uses in addition to those already described include lignin sulphonic acids and their derivatives for oilproof coating of vessels, for protection against rodents, as a size for paper, in printing ink, in agricultural sprays, as a corrosion inhibitor in locomotive and other types of boilers, as a binder for electromagnet cores, as a water softener, as an extender for battery plates, as a soap for use in hard water, as a reducing agent for dyestuffs, as an activated charcoal, as a lubricant in water dispersion paints, as a froth-flotation agent, and as a dyestuff.

Sulphite liquor is obviously a versatile and useful material. Indeed, it may well be asked, why are such vast quantities wasted? It is clear from the examples given above that the problem is economic rather than technical. First and foremost, the question of the capital investment necessary to exploit these pulping wastes arises. Installing plant to develop them is not to be embarked on lightly, for, in addition to extensive research and development facilities, the recovery and processing equipment required is by no means inexpensive. Particularly on the American continent, where there is an abundance of raw material of many types, competition from established sources of supply is severe. Sulphite waste liquor, while providing new products, must also be able to displace some, at least, of the products now available, by reason of lower cost or improved quality, or both, if it is to justify heavy capital outlay.

This has, to date, not proved an easy matter. For example, in the manufacture of alcohol there are two alternative sources, one from ethylene in the petroleum industry, and one from molasses, both of which under favourable circumstances can give alcohol more cheaply than sulphite liquor. Furthermore, a number of the outlets for the lignin derivatives described above are specific, and, therefore, limited as to the quantity disposable. For example, although the lignins are excellent dispersants, they are generally no better than the best alternatives in supply, and it is difficult to imagine a large amount being

sold compared with the total potentially available. Vanillin is another case in point—one sulphite mill could supply the whole of the world demand!

There is, however, a good and urgent case for overcoming this problem of disposing of these pulping by-products. One of the chief reasons has for many years been river pollution. The sulphite liquor containing effluent from pulp mills has a high oxygen demand, and consequently there is a danger that fish in the rivers will suffer if excessive quantities of liquor are discharged to waste. The river pollution laws, particularly of America, have become progressively more stringent over the last 30 years, until today the reduction of pollution to satisfy the prescribed requirements is a most difficult problem, particularly for inland pulp mills. The extensive and economic use of what is now a waste pro-

duct would, moreover, reduce the cost of pulp production.

A considerable number of experts in many places, particularly in North America and Sweden, where the bulk of the world's chemical pulp is produced, are working on this problem.

A vast amount of work has thus been done on this important subject, and, although a great deal of knowledge has been accumulated, there remains much to be discovered about the composition and possible uses of waste sulphite liquor. It is, however, satisfying to know that sulphite liquor is already used by industry in several ways with success. The extent of this achievement is so far limited, mainly by difficult economic problems, to only a very small part of the ultimate objective, the complete and profitable utilisation of one of the world's larger wastes.

Large-Scale Culture of Algae

AN experimental programme undertaken at the Stanford Research Institute and sponsored by the Research Corp., New York, is designed to determine the optimum conditions for maximum growth of algae and to draw up a tentative design for a continuous process for large-scale culture to supplement the supply of protein and fat. Progress made so far in this project is described by Paul M. Cook in *Industrial and Engineering Chemistry*, 1951, 43 (10), pp. 2385-2389.

Chlorella pyrenoidosa (Emerson's strain), about which there is ample information, was selected. *Chlorella* is a unicellular green alga. Requirements for photosynthesis in liquid medium include carbon dioxide, water, light, mineral and micro nutrients. It has been shown that the chemical composition of *Chlorella* can be altered by changing the environmental conditions under which it is grown. Normal rapidly growing cells have a protein content of over 50%, but by reducing the concentration of fixed nitrogen in the culture medium, cells with a lipid content of over 85% have been grown. Studies of growth and reproduction rates in various organisms showed that *Chlorella pyrenoidosa* gave the highest yield.

Algae has previously been grown largely on a batch basis, in which conditions within the culture are constantly changing. It was found, however, that the alga grows very rapidly during a small period in the life of the culture and, by maintaining conditions constant at this point of maximum growth, it was possible that greater yields could be obtained. Therefore, an experimental apparatus to maintain these constant conditions was designed. The basis of the system was a continuous supply of nutrient and a continuous harvest of cells, so that the number of cells in the system and their average age would be constant, and the nutrients would be held

at a fixed concentration. A second similar apparatus for use out of doors was also constructed and mounted on a pivot so that the column might be operated normal to sunlight.

The apparatus

The apparatus consisted of a borosilicate glass column 4 in. in diameter and 6 ft. in height, illuminated by three 100-W. fluorescent lights, about 0.75 in. from the column wall and 90° apart on the inside of a sheet-metal reflector. A cooling tube, sealed into the top part of the unit, extended almost to the bottom, water being regulated by a temperature controller. An inlet tube, near the bottom of the column, provided aeration and two other tubes were sealed into the bottom of the column, one for sampling, the other for introducing new medium. An overflow outlet at a level of 10 l. kept the volume constant, while a photoelectric cell circuit, activating a solenoid valve, controlled the entry of new medium and thus the population density of *Chlorella*. Pressure reducers and needle valves on sources of compressed air and carbon dioxide controlled the aeration mixture, each gas being metered through manometer flowmeters. Cotton gas filters were used, connections were sterile and aseptic techniques were employed. Thus, a closed sterile system was assured.

Results were measured by the overflow or harvest obtained per unit time from a constant weight of reproducing and growing cells. Light conditions in the artificial light column being constant, results were reported in terms of population density. The maximum yield occurred at a density of 0.36 g. dry weight per litre of medium, and the maximum production obtained was 0.48 g. dry weight per litre per day.

In the case of the sunlight column, light conditions were not constant, but to obtain results, overflow volume was again plotted

against time. This experiment was carried out at a population density of 0.27 g./l. The daily average yield was 0.279 g./l., while the yield for clear days was 0.351 g./l.

The optimum nutrient and culture conditions for maximum growth were found not to differ greatly from those for present methods of *Chlorella* culture, though it was apparent that the effect of micro nutrients on *Chlorella* growth is not yet fully understood. Improved media might result in increased growth rates.

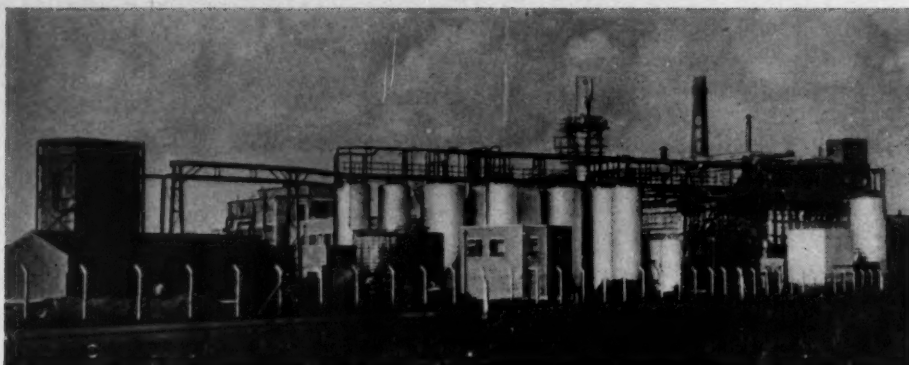
The problem of developing a process for the large-scale culture of *Chlorella* is one of the efficient uses of sunlight to synthesise organic matter. At and above a certain critical intensity of light, a cell is light-saturated and has reached its maximum rate of photosynthesis. No further benefit can be expected from increased light intensity, except that of having more volume growing at maximum rate owing to greater penetration of light through the culture. A considerable amount of light is wasted under certain conditions and this difficulty has not yet been overcome.

Population density should be maintained at 0.36 g. dry weight per litre, though this can vary $\pm 10\%$ without an important reduction in yield. Savings in equipment and processing will result if conditions can be found under which there will be little loss of yield with higher population densities.

Turbulence or agitation is a necessary condition for optimum growth. It is also essential to have a closed and sterile system. There are strong indications that certain moulds and bacteria will cause a considerable decrease in growth rates.

The large-scale continuous process suggested consists of two parts, a culture farm and processing plant. Growth takes place in long horizontal tanks of the culture farm, where optimum conditions are maintained by introducing fresh medium at frequent intervals, an equal flow being provided into each inlet to maintain population density constant. With equal dilution throughout, but removal at the end only, the flow rate of culture in the tank increases as the end is approached. The culture is recycled in sufficient quantity to obtain turbulent flow conditions. The necessary nutrients, including carbon dioxide as carbonate and bicarbonate, are introduced with the medium, and additional carbon is supplied from an atmosphere of carbon dioxide and air maintained over the culture.

The harvested culture flows to the processing plant, where the cells are separated from the medium by one of several possible systems. Waste combustion gases from the sterilisation and dehydration processes supply enough carbon dioxide for growth requirements, and one variation of the process calls for a carbonation of the spent medium. Make-up water, to which the necessary nutrients have been added, is sterilised and incorporated with the spent medium for return to the culture tanks.



Sebacic Acid made in England

Sebacic acid, an aliphatic dibasic acid of wide application in industry, is being made in England for the first time in a new plant at Manchester. The operating company was formed jointly by British and American companies and the plant is considered the most modern of its kind in the world. Here is a short description of the manufacture of sebacic acid and its uses in the fields of plasticisers, synthetic resins, rubbers and fibres.

SEBACIC acid is the highest member of the series of aliphatic dibasic acids which can be produced on a commercial scale. Chemically sebacic acid is a member of the homologous series of dibasic acids represented by the general formula:

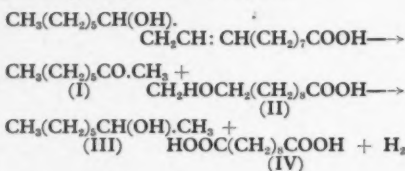


the members of which are known from $n = 0$ (oxalic acid) to $n = 20$ (the eicosane acid occurring in Japan wax). In the case of sebacic acid n is 8, so that the acid may be regarded as a derivative of either of the hydrocarbons octane or decane. Hence the names 1, 8 octane dicarboxylic acid or decane-1, 8-dicid.

Chemistry of sebacic acid

No simple synthetic method of preparation is available to industry. Instead, the starting point for all useful methods is based on ricinoleic acid or its compounds.

Castor oil is a glyceride compound of high ricinoleyl content (about 88%) containing also oleyl, linoleyl, stearyl and other glycerides. Castor oil, or a mixture of the free acids from castor oil, are treated at high temperatures with caustic alkalis such as sodium hydroxide. This reaction has been known for about a century, but researches in recent years have led to the clarification of the course of the reaction, which proceeds in two stages:

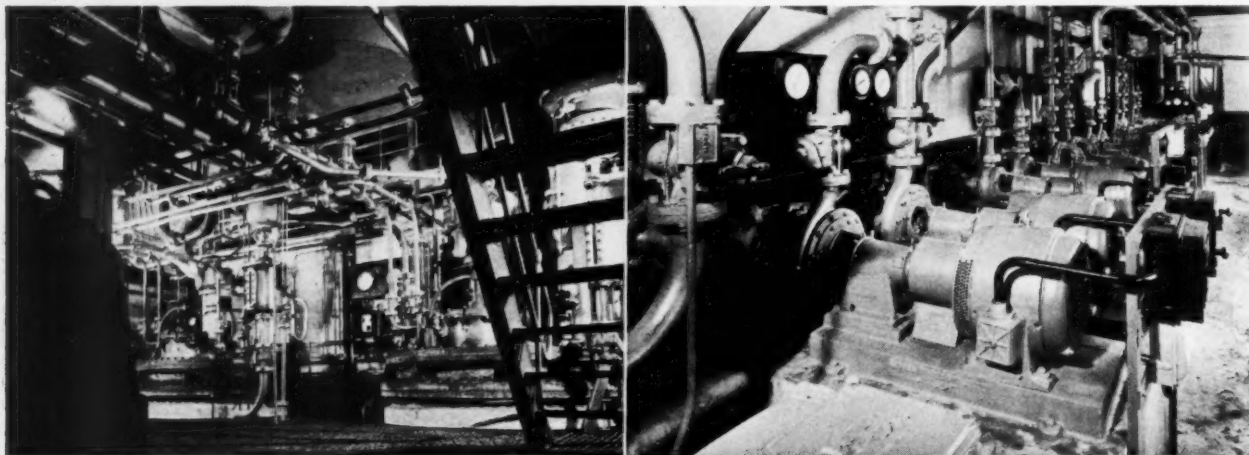


At temperatures up to 200°C. the reaction proceeds to the formation of methyl hexyl ketone (compound I) and

ω -hydroxy decanoic acid (compound II). At higher temperatures interaction of these two compounds leads to the formation of capryl alcohol (octan-2-ol, compound III) and sebacic acid (compound IV). Evidently the oxidation of the hydroxy acid occurs with the reduction of the ketone and the liberation of hydrogen.

Manufacture

The method of alkaline fission of ricinoleic acid or its derivatives has been the subject of many technical investigations of recent times. The main object has been the development of industrial processes which provide good yields, and researches have been on the lines of improving the reaction conditions, since, from the point of view of plant design, it is not easy to heat castor oil or ricinoleic acid soaps up to very high temperatures and to keep the mass in a homogeneous form. Capacious



fusion pots are required, owing to the severe foaming of the highly viscous reaction mass, while at the same time a rapid and even heating is required, since overheating as well as slow heating is detrimental. Attention must also be paid to the corrosive effect of alkalis at high temperatures. The design and choice of constructional materials for the plant is clearly of the highest importance.

At the present time sebacic acid is made on an industrial scale by two companies in the U.S.A. and one in England. The latter company arises from the collaboration of one of the American manufacturers, the Hardesty Chemical Co. Inc., with the Geigy Co. Ltd., of Manchester. The Geigy-Hardesty Co. Ltd., whose manufacture of sebacic acid and capryl alcohol has just commenced in England bases its process on that employed by the Hardesty Co. in the U.S.A., but has embodied certain refinements. Above all, it can be stated that successful economic industrial production is reached by the application of good engineering principles. Thus a plant is now in being which is the most modern in the world and is now providing, for the first time in Europe, important new chemicals on a large industrial scale.

Products of the new plant

The highest recorded melting point of sebacic acid is 134.5°C ., while the degree of acidity is shown by its neutral reaction to helianthin and the values of its dissociation constants:

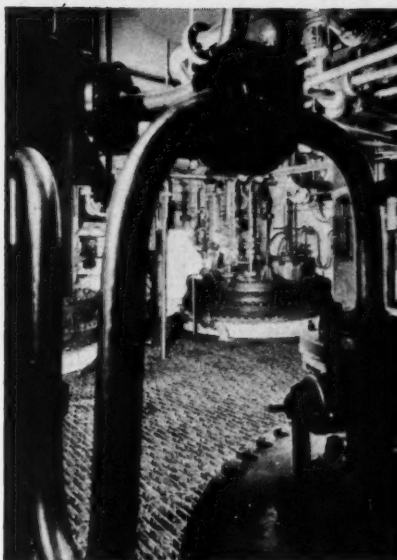
$$K_1 = 2.6 \times 10^{-5} \text{ and } K_2 = 2.6 \times 10^{-6}$$

Its boiling point at 100 mm. is 294.5°C .

Sebacic acid, as manufactured by the Geigy-Hardesty Co. Ltd., is free-flowing powder having a mild fatty acid odour. Its solubility in water is less than 0.1% at 20°C ., while in hydrocarbons, chlorinated hydrocarbons and ether it is also very low. It is freely soluble in alcohols, esters and ketones. The product conforms to the following:

Purity (calculated as sebacic acid)	98.5% min.
Colour (of 20% w/w solution in 7% ammonia)	200 Hazen max.
Crystallising point	131°C min.

Capryl alcohol, which is first obtained as an aqueous distillate, is separately refined by modern distillation methods (multi-plate and high reflux ratios) and leads to a high grade of alcohol. This finds use in the production of plasticisers (phthalate, adipate, sebacate, etc.), as an anti-foam agent, in lacquers, in solvent processes and in synthetic processes calling for the introduction of octyl groups. The purpose of the distillation is firstly to remove the water and secondly to eliminate the small quantities of methyl hexyl ketone which arise to an extent proportional to the degree of reaction between methyl hexyl ketone and ω -hydroxy decanoic acid which in practice is never 100% complete. The boiling range of technical quality capryl alcohol is 173 to 180°C . With



Special derivatives of sebacic acid are made in this plant.

good refining the content of methyl hexyl ketone falls below 1%, in which case the boiling range is within 1°C ., namely 179.5 to 180.5°C .

Applications

The properties of sebacic acid are, in general, those expected of carboxylic acids. Thus the formation of salts, esters, amides and the like proceeds normally in two stages, according to whether one or two carboxyl groups are concerned in the reaction. Of great importance is its ability to form polymeric compounds by reaction with di, tri or higher functional materials such as glycols and other polyhydric alcohols, diamines, etc.



Semi-scale plastics mixer for testing sebacic acid plasticisers in the technical service laboratories.

Diester plasticisers

The reaction of sebacic acid with monohydric alcohols gives rise to extremely useful esters. Of particular importance in this field are the dialkyl esters. This series of esters possess a unique property in that their viscosities are less sensitive to change of temperature than those of the corresponding well-known esters of phthalic, adipic and phosphoric acids, etc.

A number of the commercially available dialkyl esters of sebacic acid, examples of which are dibutyl and dioctyl (di-2-ethylhexyl) esters, are excellent plasticisers. By virtue of the above-mentioned viscosity/temperature characteristics they endow polymer compositions in which they are incorporated with a correspondingly low temperature sensitivity in respect of many of their physical properties. For example, when such plasticisers are used with polyvinyl chloride and the synthetic rubbers, properties such as hardness, moduli of elasticity and rigidity are less subject to the effects of temperature than is the case with most of the other well-known plasticisers. In consequence, such dialkyl sebacates are employed as plasticisers when polymer compounds have to conform to low-temperature specifications. In addition, the volatility of the dioctyl ester is extremely low, being of the same order as that of tricresyl phosphate, and hence good ageing characteristics are also achieved.

Because of their attractive viscosity properties, coupled with low volatility and oil solubility, the higher alkyl diesters of sebacic acid, e.g. dioctyl sebacate, are finding favour in the field of additives to lubricating oils and in the production of low-temperature greases.

Polymeric applications

The polyfunctionality of sebacic acid is best applied in the production of the following materials for industry:

(a) Synthetic resins of the alkyd or polyester type produced by reaction with glycerol, pentaerythritol, trimethylolpropane, etc. These are used as such or modified with long-chain fatty acids (lauric, palmitic, ricinoleic, etc.) in the surface coating and floor covering industries.

(b) Synthetic materials also of the polyester type are made by reaction with dihydric alcohols such as 1:2 propylene glycol, giving rise to highly viscous liquids, so-called 'polymeric plasticisers,' which are the most recent innovations in the plasticiser field. On account of their high molecular weight they are non-volatile and do not diffuse from polymers with which they are used as plasticisers. These materials constitute the group of so-called 'non-migrating' plasticisers.

(c) Synthetic rubbers made by the reaction of sebacic acid with selected glycols. The products are capable of cross-linking either by poly-iso-cyanates (the *Desmodurs* and *Vulkollan* of the I.G.) or with organic peroxides giving, for example,

the 'polyester rubber' of the Bell Telephone Laboratories.

(d) Synthetic fibres of the polyamide type; whilst adipic acid used with hexamethylene diamine produces nylon, interesting variations are being produced on an industrial scale using sebacic acid in place of adipic acid. Products from sebacic polyamide are usually in the form of monofilaments for use as bristles, tennis racquet strings, fishing lines, etc., resulting in improved resistance to water. This polymer also lends itself more readily to the production of these thicker sections. By the choice of diamine, suitable combinations arise for use in rayon manufacture, while partial admixture with terephthalic acid in the Terylene series also gives interesting new polymers applicable as plastic materials as distinct from textiles for which the ethylene-glycol terephthalic acid polyester is itself most suitable.

EVAPORATION

(Concluded from page 130)

tails are given of suitable units for the low temperature evaporators. Several references are given in the paper.

The choice of materials of construction has been mentioned in connection with salt manufacture, but this is an ever-pressing problem. An indication of the search for new materials is given by the construction of a unit for concentrating dilute sulphuric acid in which the body of the evaporator is made from *Keebush* and the tubes are of carbon. This gives, in effect, a non-metallic construction.

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Synthetic Resin Manufacture

MODERN PLANT AT BARRY, SOUTH WALES



Part of the B.R.P. works, with laboratories on the left and production buildings on the right.

THE firm of British Resin Products Ltd., which was formed in 1940 and reconstituted in 1945, is a subsidiary of the Distillers Co. The company carries out the production of a wide range of synthetic resins, both for paint manufacture and for other purposes, in a modern 56-acre plant between Cardiff and Barry in South Wales. The site of the plant is divided in two by a stream, the B.R.P. factory occupying the southern part, while the northern part is taken up by the British Geon plant as a separate entity, access to this area being restricted owing to the dangerous nature of the materials—acetylene, chlorine and hydrogen—that are handled in the manufacture of Geon vinyl chloride polymers.

The buildings at present constructed at Barry make use of only about half of the area available, so that there is ample space for future expansion. The site was previously a U.N.R.R.A. depot, and road and rail facilities were constructed when it was taken over. Four miles of roads link the buildings, and the factory is connected to Barry dock directly by rail, while since the factory layout was planned as a whole, it has proved possible to arrange production units for the greatest efficiency, and to permit, for example, the boiler house to be sited with regard to general atmospheric conditions to avoid problems of wind-blown dust.

Research and development laboratories

The work of these laboratories covers a very wide field of applications, such as the development and evaluation of resins for use in adhesives, laminates, moulding powders, brake linings, rubber and sand cores. One of the most interesting sections is that concerned with the preparation and testing of resins produced for paints and varnishes.

The research laboratories are housed in a two-storey block 300 ft. long with the individual laboratories situated on both sides of a central corridor on each floor.

A second large block houses the service laboratories and semi-scale or pilot plant. The total floor area is about 60,000 sq. ft., accommodating at the moment 150 staff, of which rather less than one-third are chemists and the remainder assistants.

In the research block, which has been designed for maximum efficiency and convenience, there are 24 laboratories of two main types. The single-unit type is sufficient for one chemist and one or two assistants, and the double-unit type for two chemists and three or four assistants. The layout of each laboratory, which has either one or two island benches, is similar in each case. In addition to the main laboratory space, a separate balance room, an office and small store room are attached to each laboratory, a feature which materially assists efficiency and neatness. The offices of the adjoining smaller units are interconnected to allow for exit in the case of fire.

The research work can be broadly subdivided into exploratory and development, the exploratory work being directed to the investigation of new resin-forming reactions and the development work to the formulation of modifications of conventional resins to meet continually improving standards of performance. Each laboratory unit is usually devoted to one particular synthetic resin field—for example, one is employed on the development of urea-formaldehyde resin plywood adhesives, while another is concerned with the improvement of etherified urea-formaldehyde resins for use in refrigerator enamel-type finishes. The chemical classes of synthetic resins examined are, of course, very broad, and among those on which research is continually being carried out with regard to eventual utilisation in the paint field may be mentioned alkyd resins, modified phenolics, phenolics, cashew nutshell liquid, coumarone indene, styrene-drying oil copolymers, aqueous polystyrene and other polymer dispersions. One laboratory is set aside for analytical work other than

that required for control purposes and others for physical and electrical testing.

Following logical practice, the library has been placed in the research block and, although it is still in process of building up, a considerable range of technical periodicals, reports and books has been acquired. A conference room for technical discussions is included here also.

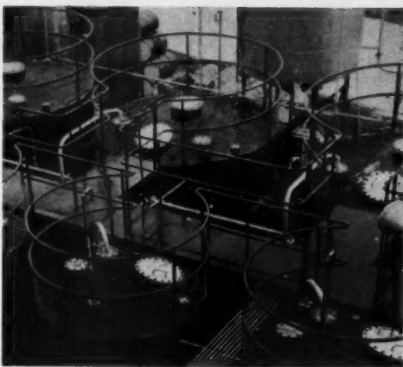
In the second block are situated the semi-scale laboratories where the manufacture of experimental products can be studied on a pilot scale before proceeding to full-scale manufacture. Vessels of 2, 5, 10 and 50 gal. capacities are employed in this small-scale production, and the steam, water, etc., services are laid under the floor, so that much more clear space is available than is usually possible. In this block also are situated the service laboratories concerned with the evaluation of experimental resins in their end uses and dealing with customers' enquiries. These include laboratories for evaluating laminating and adhesive resins and moulding powders.

In the adhesives laboratory a wide range of problems is studied, ranging from examination of resins suitable for plywood and waste wood board manufacture to those suitable for brake linings, sand cores and high wet-strength paper. The thermoplastic and thermosetting moulding powder laboratories cover the evaluation of many materials ranging from PVC, polystyrene and cellulose acetate to urea- and phenol-formaldehyde moulding powders.

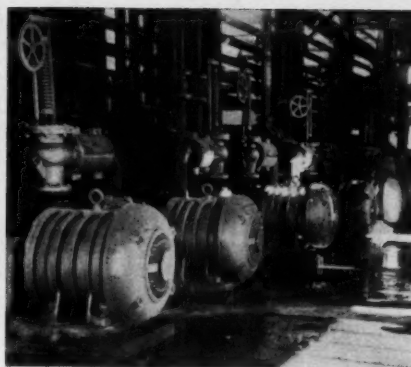


Laboratory in the research block.

Finally, there are the laboratories on the upper storey of this block devoted to the examination of resins developed for the surface-coating industry, including a compounding room with ball mills and triple-roll mixer, a varnish laboratory for the cooking of varnishes, a spraying room, a drying room, eventually to be fitted with temperature and humidity control, a stoving room and a general-purpose laboratory where miscellaneous work is carried out. The equipment includes a weatherometer. Among the main problems currently being studied is an investigation of the crazing of urea-based wood lacquers in addition to the evaluation of the large number of experimental resins for surface coatings and insulating varnishes which are continually



Left: Alkyd blending tanks at the Barry works.



Right: Part of the low-temperature resin blending system.

being fed from the research laboratories.

An extension of this block houses the master control laboratory, which is responsible for incoming raw material analysis and the supervision of the production testing carried out in the decentralised production laboratories. A further wing contains a workshop to deal with problems of experimental plant maintenance.

Production buildings

There are four production buildings at the factory, each of which is self-contained, having its own satellite tank farm, pumping installation, stores and dispatch bay. The general arrangement is that a control laboratory is at the centre of each building with a wing on either side for production. In the case of the main resin building, for example, urea resins are made in one wing and phenolics in the other, full drum storage being provided at each end. A second synthetic resin building manufactures alkyds, modified phenolics, coumarones and cashew resins, together with various high-temperature resins. The other two plants are concerned with the production of thermosetting and thermoplastic moulding powders.

Almost all of the resins in the first two buildings mentioned above find applications in the paint and printing ink industries. Urea-formaldehyde resins, for example, which are produced by reacting urea and formaldehyde, are used for dipped and sprayed stoving finishes, having high gloss, rapid cure and compatibility characteristics. Phenolic resins, made from phenol and formaldehyde in a condensation reaction, are employed in paper laminates. Alkyd resins, the reaction products of phthalic anhydride and glycerol, have many uses in the manufacture of enamels and other finishes and also in printing inks. Coumarone-indene resins, mixed polymers of coumarone and indene, are pale neutral resins which may be employed in aluminium-bronze paints and vehicles, metal primers, ship paints, chemically-resistant finishes and printing inks; they have good colour and solubility in both white spirit and drying oils.

In order to ensure consistent production, extensive laboratory control is exercised. Every precaution is taken to avoid contamination and each liquid raw material has its own pipeline from storage tank to reaction vessel. In addition, where necessary, stainless steel equipment is used. An elaborate system for blending liquid resins is employed to eliminate any difference between batches.

The Geon plant, on which construction first began in April 1947, produces a range of polymers based on vinyl chloride, which is synthesised from hydrogen chloride and acetylene. Coal, chlorine and calcium carbide are the major raw materials used, and there have been three major expansions in the last four years. At present, most Geon products are used in sheeting and extruding applications, but some vinyl and vinylidene chloride copolymers are suitable for application from solvents for surface coatings.

Other buildings

The two major buildings, which are separate from the production area, are the welfare and administration blocks. Both of these are designed in a modern style and, although very long in relation to their height, do not appear disproportionately so, owing to the vertical structure of the window glazing being emphasised. The welfare building has canteens and cooking facilities on its upper floor, the workers having a cafeteria system for the collection of meals. On the floor below are rest rooms, first-aid arrangements and a well-equipped medical department. The administrative building contains offices for executive staff and office workers, and has a large conference room for directorial use. The area between these buildings is being turfed, a feature that can be expected to add to the amenities of the site. Although there is obviously more scope for architectural design in these buildings, the grouping facing the entrance to the plant creates an excellent impression of purpose and efficiency, an impression which is reinforced when the main production facilities have been visited.

Modern Wood Preservatives

The importance of the wood preserving industry is increasing as wood becomes more and more expensive. For years, creosote has been the most widely used preservative, but with the gradual increase in its price, alternative substances have been developed. In North America, with abundant supplies of cheap mineral oil, a preservative mixture of 50% creosote and 50% crude petroleum is now widely used for railway sleepers, telegraph poles, etc. Besides being cheaper than straight creosote, it has certain technical advantages. In Britain and other countries where petroleum is not so cheap, water-soluble salts such as fluorchrome, and copper sulphate and dichromate have been developed. Much work remains to be done on developing effective and cheap preservatives and efficient plant for their application. Current practice in wood preservation was described and discussed at the first annual convention of the British Wood Preserving Association, held at Cambridge last year. Below are summaries of papers dealing with the preservation of railway sleepers and green timber, laboratory testing of preservatives, fire-retardant chemicals and the wood preserving industry in North America.

Preservation of railway sleepers

PRESERVATIVE treatment of a railway sleeper must be such that it shall not fail owing to premature decay during the life of the track, in Great Britain, 17 to 20 years for a first-class track. When the sleepers come out of a first-class line many of them are re-used on secondary lines or in sidings so that in preservative practice it is necessary to keep in mind a desirable minimum life of about 40 years.

A discussion of preservatives for railway sleepers was given by W. ROTHWELL of British Railways. The pre-eminent preservative is still creosote, which has been from the commencement of wood preservation the traditional method, in the first place with the 'Bethel' or full cell process, and later with the 'Rueping' or empty cell process. Creosote possesses all the desirable qualities in a preservative. It is highly toxic, permanent, non-corrosive, able to give deep penetration, safe and easy to handle, etc. It was originally a cheap material, but with the development of oil technology larger quantities of creosote were used for distillation into more remunerative products. Today, therefore, it is much dearer and less plentiful. In America this tendency was met by adding crude petroleum to creosote and a 50:50 mixture is now widely used. With petroleum at about one-quarter of the price of creosote an appreciable reduction in costs was made, but an unexpected and interesting technical improvement was also made. The petroleum tended to keep the surface more oily and so restricted evaporative changes; also, sleepers treated with creosote/petroleum mixtures were less subject to surface shakes and warping. In the U.K. this way out of the difficulty was not an economic proposition, and the line of development has been to extend the use of water-soluble salts for sleeper preservation.

Creosote, when properly applied, has never failed the railway engineer, but water-solubles have not been used on such a large scale for such a long period as to be absolutely sure that they will give a toxic protection equal to that of creosote over the whole life of the sleeper of say 40 years. The water-solubles so far used are of the fluorchrome and copper sulphate/di-

chromate groups and are at least as toxic as creosote when used in the concentrations specified by the manufacturers. One of their inherent disadvantages is their water solubility. Although fixation of the salts in the timber does take place, leaching also occurs. An increase in the conductivity of the sleepers caused by the use of the salts has also created difficulties in connection with signalling in some instances.

Sleepers must be treated to give a regular supply to the line all the year round. In recent years a total of 700,000 to 800,000 treated sleepers have been called for plus large quantities of timber for switches and crossings for the London Midland Region alone. These have been supplied from two depots from where as many as 10,000 sleepers are sent out from each during each week of the busy season. One depot is completely modernised and has three cylinders operating exclusively on water-solubles. It is equipped so that it can treat by the empty cell process, but in the existing conditions no schedules using this process are being used. Various experimental schedules, including pre-steaming, have been tried and it has been found that better and deeper absorptions have been obtained with salts than with creosote, possibly due to the incomplete seasoning of the timber. The other depot is a typical layout for treatment of Baltic Redwood by the full cell process, but here again a modernisation scheme is in progress. An incising machine is being installed and high capacity circulating pumps are to be fitted to give better control of temperature in the cylinders and a higher temperature for the creosote. At the moment the plant is operating one cylinder on creosote and one cylinder on water solubles. When the alteration is completed some experimental work on the lines of the boiling under vacuum process will probably be carried out. At both plants autographic recording instruments are used for all operations which enable a close control to be kept on the treatment.

Protection of green timber

By creating an efficient chemical barrier before infection, i.e., as soon as possible after felling, certain wood diseases can be

avoided. The use of chlorine derivatives for the preservation of fresh, unbarked and sawn, timber was described by H. ALLIOT, technical director, Xylochemistry Co., Lyons, France.

Experiments have been carried out in France from which the following information was obtained. Salts in aqueous solutions are liable to leach out in the rain and organic solutions do not penetrate into the superficial strata. Oily emulsions in water give the best results. Application by brush was shown in general to be impractical because it takes too long and does not penetrate irregular surfaces. Spraying is carried out more rapidly and provides the most satisfactory method.

The chlorinated phenols have been tested in the laboratory and in the field. Pentachlorophenol, an excellent fungicide, has not proved effective against the wood termites. On the other hand, the *gamma*-isomer of benzene hexachloride has given interesting results. It has been applied by spraying in the form of an oil-in-water emulsion. However, a dual-purpose formula is required containing both adequate fungicide and insecticide bases. Satisfactory results have been obtained with *Cryptogil EA 6*, which is a chlorophenol containing a proportion of the *gamma*-isomer of benzene hexachloride.

Chlorinated phenols can be used for protecting sawn timber either by soaking or by spraying in a closed cylinder. The treatment is carried out mechanically. The wood is transported by chains and dipped for a few seconds in a bath. As it ascends the draining board the surplus liquid runs back into the bath. The cylinder system is often preferred, the timber being subjected to a fine spray inside the cylinder, the surplus liquid being collected at the bottom and re-circulated. Pentachlorophenolate solutions have been used as well as benzene hexachloride where a more powerful agent is required.

Further, in France the preservation of telegraph poles is carried out either with mercury bichloride in an enclosed cylinder or by injection into the sap by the Boucherie process of copper sulphate. The efficiency of the chlorophenols has led to their use for this process. Although early experi-

ments were not encouraging, a product on a chlorophenate base has been developed which gives excellent protection and defies leaching through atmospheric conditions.

Wood preservation in the U.S.

Through the Economic Co-operation Administration scheme N. A. RICHARDSON, Officer-in-Charge, Wood Preservation Section, Forest Products Research Laboratory, visited firms and research institutions concerned with wood preservation in the U.S.A. and Canada. He said that the wood preserving industry in the U.S.A. is a very extensive one and is still expanding and, in general, the treating plants are more modern than those over here, having usually been designed by engineers specialising solely in this particular field. Plants are also designed to deal with the particular class of material to be handled, so that in the N.W. States, where Douglas fir is commonly creosoted by the Boulton process, most of the plants have been built to carry out this treatment in the most efficient manner with the Rucping cylinder used as a vapour drum and external creosote heaters and a highly efficient steam ejector and condenser vacuum equipment as standard. Cylinders are efficiently insulated allowing high oil temperatures to be used economically and resulting in better and cleaner oil treatments, and, as many are under cover, better working conditions as well. Practically all the treating yards seen were well laid out to ensure efficient working, and extensive use was made of mechanical handling and processing equipment. Much attention is paid to plant control and, in addition to a good operations room, a well-equipped laboratory is regarded as an essential part of the plants, which are under the charge of highly-skilled technical staff often University trained. Treating schedules and the results of treatments are usually worked out by the laboratory staff, who also keep records such as rates of absorption, etc., for all treatments, and many of the firms visited had small experimental pressure plants. Preservative treatments are in general in accordance with appropriate specifications issued by such organisations as the American Wood-Preservers' Association, American Railways Engineering Association, and the U.S. Government. Pressure treatments are carried out to a high standard, and with refractory timbers, such as Douglas fir, long treatments are often employed, even with incised material, as it is recognised that these are necessary to obtain satisfactory penetration. This is very significant when one remembers that wages are much higher than in Great Britain, where it is frequently said that labour costs will not permit long treatments. Present-day practice in the treatment of Douglas fir in the U.S.A. and Canada is to employ high oil temperatures (200 to 210°F.) and moderate and slowly raised pressures of the order of 120 to 140 lb./sq.in.

Coal tar creosote is by far the most

widely used wood preservative in both the U.S.A. and Canada, and in 1949 over 94% of all the timber preserved in the U.S.A. was treated with either creosote or creosote mixtures. Creosote is used for the pressure treatment of poles and piling, and in addition mixtures of creosote with coal tar or petroleum oil for railway sleepers. Creosote or other oil type preservatives are recommended in all specifications for timber used in contact with the ground or where leaching is an important factor. The use of water-borne preservatives for the preservation of sleepers in the U.K. was the subject of adverse comment several times during the tour, as it was considered a retrograde step and contrary to experience in all parts of the world, which had clearly shown the superiority of oil preservatives for sleepers. Members of the lumber and preserving industries in British Columbia were particularly critical of the use of salts for sleeper preservation, expressing the view that with the high price of timber today it was more than ever essential to use the best method of preservation and to obtain the longest life possible.

The present tendency in the U.S.A. is to favour creosote-coal tar mixture for sleepers as these are believed to be more effective than either creosote or creosote-petroleum oil mixtures in reducing the incidence of splitting and other mechanical degrading in service. Experiments carried out under the aegis of the A.R.E.A. have shown too that coating the exposed surfaces of sleepers in the track with bituminous or coal tar preparations is very effective in reducing splitting of hardwood sleepers.

During his visit, Mr. Richardson attended the annual meeting of the American Wood-Preservers' Association. The most debated resolution at the meeting was one submitted by the Wood Preservatives Technical Committee to make certain amendments to the A.W.P.A. specification for creosotes. The new clause that aroused the most controversy defined limitations in the specific gravity of the fractions distilling between 235°C. and 315°C. and between 315°C. and 355°C. to not less than 1.025 and 1.085 at 38°C., respectively, compared with water at 15°C. The purpose of these limitations was intended to ensure that creosote does not contain petroleum oil as an adulterant, but in practice they would also exclude creosotes other than those obtained from coke oven or horizontal retort tars. This would mean excluding the creosote oil obtained from Great Britain, and the proposed alteration was strongly opposed by the importers and many creosoting firms, particularly those in the West, who have for many years past used only English creosote. They affirmed that English creosote has given excellent results and that, in fact, many of the service records collected by the A.W.P.A. were of structures impregnated with English oil. After considerable discussion a vote was taken

and the Technical Committee's recommendation carried. Another resolution was subsequently proposed and carried, however, that meant that any new standard should be provisional for one year so that the proposed new standard for creosote could not be immediately adopted.

Laboratory testing of preservatives

Testing the value of preservative treatments intended to enhance the durability of materials presents special problems. The testing of wood preservatives, discussed by W. P. K. FINDLAY, presents special problems because (1) any treatment of practical value must render the material proof against attack for a considerable number of years, a period much longer than any reasonable period of laboratory test, (2) timbers vary not only in their chemical and physical properties but also in their permeability to fluids, and (3) the treated material may be exposed during its life to a variety of destructive agents of which only a few can be used in the laboratory. The final and conclusive test of any preservative must always be in actual service.

Field exposure tests have been used extensively to determine the value of wood preservatives and much useful information has already been obtained. The main disadvantages of such tests are the long time required, the high cost of setting up and maintenance and their unsuitability for testing preservatives intended for use under cover in buildings and mines where leaching with rain does not occur.

The testing of the desirable characteristics that an effective wood preservative must have in a laboratory was considered by the author. Up to 1930 the usual method of determining the toxicity of wood preservatives to fungi, which was especially employed in the U.S.A., was to prepare graded series of concentrations of the preservative in solution or emulsion in a nutrient agar jelly which was subsequently inoculated with small pieces cut from pure cultures of various wood-rotting fungi. Later this was replaced by a wood-block test which consists basically in exposing to fungal attack under controlled conditions a series of small pieces of non-durable timber impregnated with various concentrations of the substance under test. This method is certainly capable of giving very useful results from which it is possible to deduce the minimum concentration in the wood of any chemical necessary to inhibit attack by any given fungus. In recent years the use of soil in place of agar as the sub-stratum on which to grow the test fungi for wood block tests of toxicity has increased. It is claimed that wood rots more vigorously in contact with soil, presumably owing to infiltration of nutrients from the soil, and that the control of the moisture content of the blocks is easier than when agar is used.

By further laboratory tests the other wood preservative properties which in-

clude permanence, penetration, corrosiveness to metals, toxicity to animals, and paintability, can all be determined to a useful degree and it is possible to discover which materials are likely to be of value without having deleterious effects on animals and on other materials such as metals.

After consideration of the information obtained from such tests one can decide whether the material is worth testing in the field or on service trials. It is not possible from laboratory tests to estimate the life of woodwork that has been treated with any particular product. There are so many factors influencing the 'life' of timber in any situation that it is futile to attempt to reproduce them all in the laboratory.

Fire-retardant treatments

Various tests have been designed to measure the effectiveness of treatments that reduce the liability of wood to catch fire, but many of them give conflicting results, largely because they have failed to stimulate practical conditions. D. L. SIMMS outlined work carried out at the Joint Fire Research Organisation (D.S.I.R.) dealing with the more fundamental aspects of the ignition of wood which should help towards a better understanding of the practical hazards involved in the use of timber, and of the merits of protective treatments.

The critical intensities of heat necessary

for pilot and for spontaneous ignition were determined for a large number of specimens of different woods and it was found that they were, respectively, approximately the same for all the woods examined.

Paint is, of course, a common covering for wood, and experiments have been carried out with ten common types of paint on western red cedar. It was observed that the paint ignited first, but as there was only a limited supply of volatiles the flame did not persist. This first ignition was followed by that of the wood itself, protected by the charred layer of paint. The best results for spontaneous ignition were obtained with gloss paint on ester gum medium, flat wall finish, and pigmented polyvinyl oil emulsion.

No fire retardant treatment can be completely effective, for any wood, no matter how treated, decomposes when raised above a certain temperature. Two main types of treatment are available, namely impregnation or surface treatments. The impregnation of wood with certain chemicals appears to increase the amount of charcoal formed by the wood and to reduce the amount of inflammable volatiles. Surface treatments appear to act by covering the surface with a coating of low inflammability and low thermal conductivity. The best available fire retardant paints are those which bubble-up, expanding to form a non-inflammable coating with extremely low thermal con-

ductivity. The measurement of the critical intensities of fire retardant treated fibre insulation board showed that with pilot ignition the critical intensity is not changed by the addition of a second coat of the same paint. The best results were obtained with one and two coats of phosphate resin and one coat of oil paint. The results were not so good with one and two coats of phosphate resin and two coats of oil paint.

The experiments described by the author enable not only paints and other fire retardant treatments to be classified in order of merit but, since the actual amounts of radiation required for ignition are known, it is possible to assess the effect of treatments on the hazard of ignition of timber in any practical situation.

The rate at which heat must be given to a wooden surface to cause it to ignite spontaneously is nearly twice as great as that required for ignition in the presence of a pilot flame, and these amounts of heat seem to be constant, irrespective of the species of wood. The amount of heat required for ignition is increased considerably once the wood has received a fire retardant treatment and such treatments are valuable in the prevention of ignition. Fire retardant treatments also delay the spread of flame from the point of ignition, but once the whole compartment has become involved in fire, treated surfaces do not affect the time taken by the fire to spread beyond the room of origin.

New standards

Filter flasks. The first British Standard to be published for filter flasks has been prepared with careful attention to the manufacturing problems involved. Eight sizes of filter flask are specified from 100 ml. to 20 l. nominal capacity. Full dimensions and appropriate tolerances are given, but for a few dimensions temporary tolerances are also listed to cover present production in view of the manufacturers' heavy investment in moulds. For flasks over 250 ml. in nominal capacity an alternative form of vacuum connection is specified, consisting of a detachable side-arm fitted by means of a resilient grommet into a hole in the flask wall. A tapered neck is specified, which is convenient for use with a rubber stopper or can be ground with an interchangeable joint if required, and other clauses cover quality of glass, general construction and wall thickness. The new Standard (B.S.1739:1951) costs 2s., post free.

Rubber conveyor and elevator belting. A revision of B.S.490, 'Rubber conveyor and elevator belting,' has been issued. This document was originally published in 1933 and was revised as a War Emergency edition in 1943. The new document reverts, to a great extent, to the original standard of 1933, but now has five weights of fabric as well as three grades of rubber cover.

The standard also gives details regarding the construction of the belting as well as stipulating limits for defects, tolerance, strength of fabric and adhesion. Methods of test are given in the appendices, where information is also contained regarding suggestions for the selection of belting; the appendices also contain recommendations with regard to service conditions. Additionally, an appendix is included stating the information which should be given with the enquiry. In view of the present shortage of cotton, an amendment slip is being published simultaneously with the document, temporarily relaxing the strength of the fabric by 5%. This standard (B.S.490:1951) costs 3s., post free.

Raw copper analysis. This new standard, 'Methods for the analysis of raw copper,' includes methods of analysis (sampling, apparatus, reagents and procedure) for the elements (except oxygen), for which definite limits are specified in B.S.1035-40, 'Raw copper,' and B.S.1172-74, 'Deoxidised and arsenical coppers.' A method for the determination of sulphur is also included, although limits are not specified in the above standards.

The methods have been found to give reliable and reproducible results and, while in some instances they may appear to be lengthy, it should be realised that they are intended to be 'referee' methods to be used in cases of dispute. Each method is

distinct and is designated by a separate 'part' number. This standard (B.S.1800:1951) costs 5s., post free. Each of the above standards may be obtained from the British Standards Institution, 24 Victoria Street, London, S.W.1.

Chemical reactions

The fourth volume* of this valuable compilation of chemical reactions covers the elements iron, lanthanum, lead, lithium, magnesium, manganese, mercury, molybdenum and neodymium, and is divided into sections in that order. A number of duplicates and near duplicates which were encountered have mostly been removed and other reactions substituted whenever possible. In some cases no substitutions could be found which fitted into the alphabetical scheme of the encyclopaedia, so certain duplicates were omitted.

There is a list of abstractors and a list of journals used by them, as well as two indexes to reagents and to substances obtained.

The editor and his collaborators are to be congratulated on the progress they are making in compiling this outstanding work of chemical reference.

**Encyclopaedia of Chemical Reactions.* C. A. Jacobson, editor. Vol. 4. Reinhold, New York; and Chapman & Hall, London, 1951. Pp. 790, including indexes, 112s. net.

Improved Petrol-from-Coal Plant Developed in the United States

Successful completion of the second integrated test run of the new American Bureau of Mines gas-synthesis demonstration plant at Louisiana, Missouri, was announced recently. Lasting for 25 days, this run marked a milestone in a research programme which is claimed to have greatly improved the German Fischer-Tropsch process of producing petrol and other liquid fuels from coal and adapted it to American conditions. One of the main advantages of the process, as explained in the following article, is the elimination of the shift reaction formerly considered necessary in preparing synthesis gas for conversion to oil.

THE plant was started on October 23, after changes shown to be desirable by the initial eight-day shakedown run that ended on September 12 had been made. By November 28, when a routine shutdown was made, enough raw gasoline and diesel fuel had been produced to permit later final refining of these products to meet specifications.

Although the primary purpose of the run was to show that all phases of the process and equipment were operable and no attempt was made to obtain maximum production, John J. Forbes, Bureau Director, said that appreciable quantities of representative products were made. Sufficient amounts of motor-grade gasoline and diesel oil were produced in barrel lots to allow for their practical testing and evaluation. During the run more than 52,000,000 cu. ft. of synthesis gas was made and treated to yield the synthetic fuel product. This amount of gas required more than 700 tons of coke and 450 tons of 95% pure oxygen.

The successful operation of the demonstration plant is a major achievement of co-ordinated research. Over a period of several years Bureau technologists working in laboratories, pilot plants and demonstration plant have co-operated effectively to bring a gas-synthesis process adapted to American coals from the idea stage to practical operation. It is unusual for a new plant to operate so smoothly for so long a time in an early run.

The gas-synthesis process is one of the three major methods for producing synthetic oil on which the Bureau is working intensively. The others are coal hydrogenation and the processing of oil shale. In the gas-synthesis process, the coal is first converted to synthesis gas, composed of carbon monoxide and hydrogen, and this, in turn, is converted into oil by passing it over an iron catalyst.

Synthesis gas accounts for about 60 to 70% of the cost of gasoline produced from coal by the gas-synthesis process. This fact emphasises the importance of reducing the cost of gas production.

During the recent run from 75 to 85% of the synthesis gas was converted to oil during a single pass. If the conversion can be raised to 90% Bureau technologists believe that the process can be operated with

a single conversion stage instead of the two stages formerly considered necessary.

Although synthesis gas for the two trial runs of the new plant was made by treating coke with oxygen and steam, later it is intended to make this gas directly from coal. Both the additional cost of producing coke and the need for conserving reserves of coking coals to meet the needs of the steel industry make coke impracticable as a raw material for large-scale operations in the U.S.

The economical gasification of coal, Bureau technologists point out, is the greatest problem remaining to be solved in connection with developing the gas-synthesis process to the point where private industry might be interested in adopting it for converting coal to oil. The Bureau of Mines is working on this problem in its laboratories at Pittsburgh, Pa., Morgantown, W. Va., Grand Forks, N. Dak., and Denver, Colo., and results obtained thus far are encouraging. The Bureau also is conducting experiments on the underground gasification of unmined coal at Gorgas, Ala., in co-operation with the Alabama Power Co.

The gas-synthesis process, perhaps better known as the Fischer-Tropsch process, has been known in Germany since 1926, and the Bureau began studying it and other synthetic liquid fuels processes in a small way at the Central Experiment Station at Pittsburgh about 1928. The present intensive research on this and other methods of producing liquid fuels from coal and oil shale, however, did not begin until 1944, when the Congress passed the Synthetic Liquid Fuels Act and made funds for these studies available after a lapse of 12 years.

Since 1944, Dr. W. C. Schroeder, now an Assistant Director of the Bureau, has been in charge of the Bureau's synthetic liquid fuels research and investigations. These studies have brought the production of synthetic liquid fuels from oil shale, and from coal by direct hydrogenation, to the point where these processes are about ready for adoption by private industry.

German technique improved

Although the Germans operated commercial Fischer-Tropsch plants, the reactors they used for converting the synthesis gas to liquid fuels were cumbersome affairs with numerous small tubes

through which the gas was passed over the catalyst. This made them expensive and required large quantities of steel. Up to the outbreak of World War II, which undoubtedly slowed their research, they had been unable to build a reactor with a capacity of more than 20 barrels a day. This meant that a large plant would require many converters, with correspondingly high requirements not only for materials but for operating manpower.

The principal problem in designing a reactor for the gas-synthesis process, according to Dr. Schroeder, is that of removing the large amount of heat evolved. If this is not done, the catalyst heats up and becomes useless. The solution used in the German wartime plants was to cool the small catalyst-containing tubes with water or steam. This method of cooling resulted in low throughput and was not practicable for large units, which accounts for the small capacity of the German reactors.

The type of reactor used by the Bureau of Mines at Louisiana requires less steel, is simple to construct, and has a capacity six to eight times that of the German reactors per unit of volume. In addition, it can be built to produce 1,000 or more barrels of oil a day if desired.

Development of reactor

Development of the Bureau type of reactor was not accomplished overnight. Early experiments at Pittsburgh and at nearby Bruceton, Pa., where the synthetic liquid fuels laboratories were dedicated in May 1948, involved placing the catalyst in an oil bath through which synthesis gas and hydrogen were passed. The idea was to cool the catalyst by evaporation of the oil. This method, which originated in Germany, proved unsatisfactory and was abandoned.

Next, the Bureau scientists tried using a high-boiling-point oil to cool the catalyst, passing this oil through an external heat exchanger which reduced its temperature, just as the water used to cool an automobile engine is passed through the radiator to prevent overheating. This solved a number of problems. It was found, however, that after the converter had been operating a while, its capacity was severely reduced because the particles of catalyst, still in a fixed bed, cemented together.

The Bureau research workers finally overcame this difficulty by speeding up the flow of gas and oil enough to lift the bed of catalyst particles and keep them whirling. In working out this development, two pilot plants at Bruceton, each with a 3-in. reactor and a capacity of 3 gal./day, were operated over a long period. A similar solution of the problem has been proposed by the Texas Company as evidenced by a patent issued to one of its employees. For scientists working independently upon a problem to reach the same solution is by no means unusual.

After sufficient experience had been obtained in the small plants, the Bureau constructed a barrel-a-day plant at Bruceton, with a converter 8 in. in diameter. Meanwhile work of designing and building the demonstration plant at Louisiana was begun. This plant, which was completed in 1951, is near the coal-hydrogenation demonstration plant that went into operation in 1949.

The gas-synthesis demonstration plant

at Louisiana includes a 1 ton/hr. Linde-Frankl unit to produce oxygen for gasifying coal. It also includes coal handling and preparation facilities, a process steam superheater, a Koppers dust gasifier, an oxygen-blown gas producer maintained as a substitute gasification unit, a synthesis-gas purification unit for removing dust and sulphur impurities, the reactor system itself, and product recovery and refining facilities.

The efficiency of the gas purification unit, based upon laboratory and pilot-plant studies at the Bureau's Morgantown, W. Va. station, is especially gratifying. This unit operates at a pressure up to 450 lb./sq. in., and it sends to the converter synthesis gas containing well under 0.05 grains of sulphur per 100 cu. ft. This is less than half the 0.10 grains per 100 cu. ft. considered permissible for the gas-synthesis process. Purification of gas under pressure is a departure from German practice and makes possible the elimination of one step in the purification process.

Catalyst

The reactor at Louisiana, Mo., has an inside diameter of 3 ft. and is about 20 ft. tall. (Originally it was designed to have an inside diameter of 6 ft. for use with a fixed catalyst bed, but this was cut down because of the greatly increased capacity possible with the jiggling bed.) A significant improvement over former practice that has been incorporated in its operation is using a low-cost catalyst. By a simple method, the Bureau in recent months has produced 38 tons of an electrically-fused catalyst, the chief ingredient of which is ordinary mill scale, a waste product of steel-rolling mills.

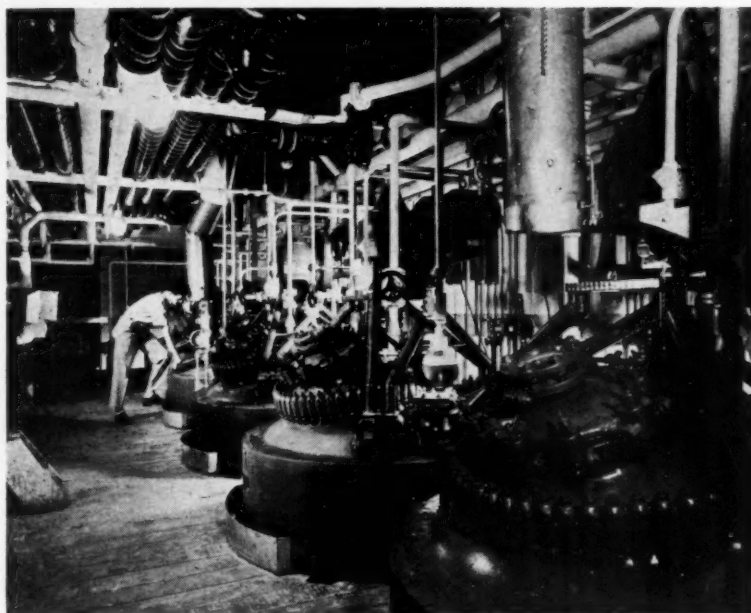
One of the major advantages of the process used at Louisiana, Dr. Schroeder explained, is that it permits using gas of the type that can be produced directly from coal, without the need of raising the ratio of hydrogen to carbon monoxide. This eliminates one step (the shift reaction) formerly considered necessary in preparing synthesis gas for conversion to oil.

Acetylene Reactions Used in Large-Scale Synthesis of Vitamin A

An outstanding achievement of the modern pharmaceutical industry has been the large-scale manufacture of synthetic vitamin A. Although the starting materials are simple and plentiful, the 12-stage process whereby they are transformed into highly purified vitamin A is extremely complex. One of these steps involves the reaction of methyl vinyl ketone with acetylene under pressure to produce a highly unsaturated methyl pentol. The elaborate engineering detail necessary for the design and construction of the unit for this hazardous process is typical of the plant as a whole.

FOR the first time synthetic crystalline vitamin A is being produced on a commercial scale by Chas. Pfizer and Co. Inc. at their Groton, Connecticut, plant in the U.S. New manufacturing techniques, using this highly purified material, have resulted in the development of products having a very high degree of adaptability to varying processing conditions. Thus, vitamin A palmitate and a dry crystalline vitamin A acetate stabilised are now available. The latter material, a dry, free-flowing, stable product, makes possible the incorporation of vitamin A in tablets and also the fortification of dry foods. Since the synthetic vitamin A has no fishy odours or flavour, its use in pharmaceutical and food outlets is particularly advantageous.

Although the raw materials for the production of synthetic vitamin A are simple and readily available, the chemical reactions involved are complex. In brief, the complex molecule is built up in a 12-step preparation using citral from lemon-grass oil as the basic starting material. A series of condensation reactions convert this product to β -ionone and subsequently to a C-14 aldehyde. Concurrently, acetone

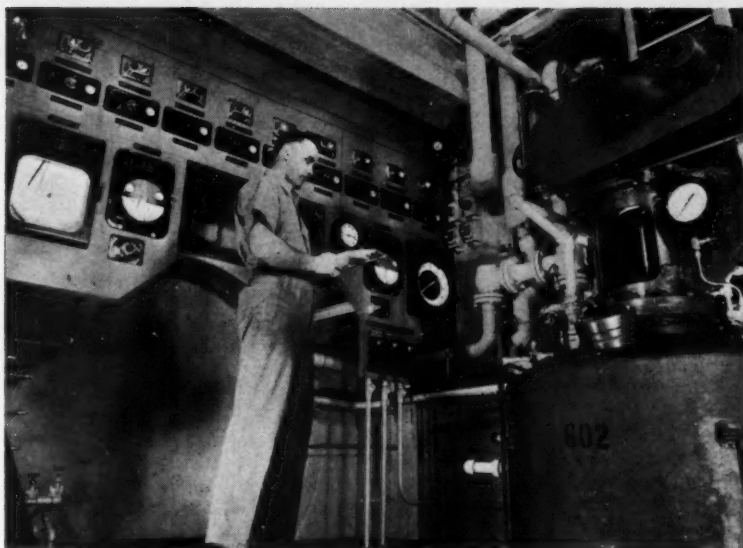


One step during the production of the C-14 aldehyde.

and formaldehyde are condensed together and converted to methyl vinyl ketone, which is then reacted with acetylene under a slight pressure to provide a highly unsaturated methyl pentol. The C-14 aldehyde as well as the methyl pentol are carefully purified by distillation and the pure products then joined together by means of a Grignard reaction to form the basic structural skeleton of vitamin A. Subsequent steps in processing are primarily devoted to the production of a highly pure crystalline vitamin A acetate or other forms of the vitamin derived from the acetate.

Because of the complexity of the reactions involved, a considerable amount of engineering detail was necessary in designing this plant. Equipment is varied. Glass-lined reaction vessels predominate, although in certain cases stainless steel is used. The majority of the piping which carries the chemicals is of stainless steel. Packed stainless steel fractionating columns, the highest 30 ft., provide distillation capacity. Certain products which cannot be conveniently handled at atmospheric pressure are distilled at vacuums of 10 mm. Hg and below. These vacuums are obtained by the use of both oil pumps or steam ejectors. Since much of the processing is carried out in the cold, adequate refrigeration is required. High-speed ammonia compressors are used to provide the primary coolant, with either brine or cold water piped to various sections of the plant. Since cooling requirements may vary, a completely flexible system has been provided by using separate heat exchangers for both brine and water, manifolded ammonia to each exchanger as required.

Due to the presence of the high degree of unsaturation in the molecule, vitamin A has a very marked tendency towards decomposition when in contact with air, undoubtedly the result of peroxide formation. Thus, vitamin A must be protected from



The control panel for reaction of methyl vinyl ketone and acetylene. The reaction chamber is behind the steel partition completely isolated from the area where operator works.

air during processing, and for this reason nitrogen lines are available throughout the plant. To provide maximum efficiency in operation, nitrogen headers carry approximately 100 lb./sq.in. and reduction to operating pressure is accomplished at the individual units. Liquid nitrogen deliveries are made by tank truck and transferred into a central storage system.

Acetylene reactions

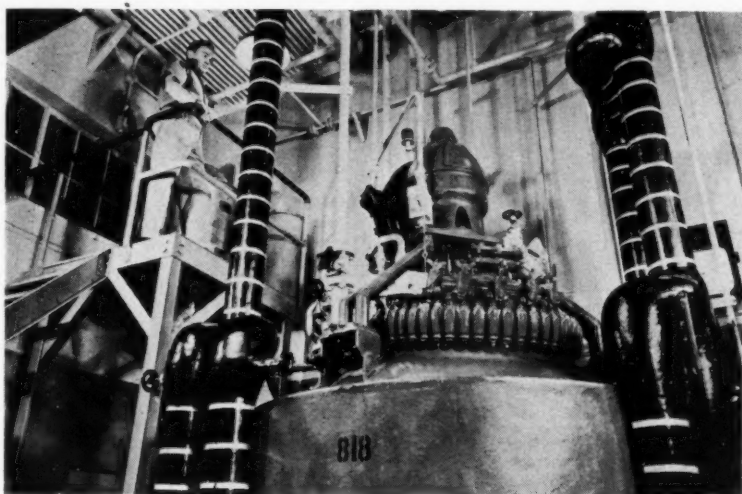
The use of acetylene under pressure in chemical operations was formerly considered hazardous and impractical. However, from the work of Reppe in Germany, which has been continued and expanded by various laboratories in the United States, have come certain principles and techniques for such reactions. Thus, at Groton, the steps involving acetylene are

handled in a specially designed outside room separated from the operator and other processing by a concave head of special construction to provide the necessary protection in case of accident. Interlocking controls extend to the operator's station, and a system of vents and pressure relief valves has been provided so that it is unnecessary to enter the reaction area when a potentially hazardous situation might exist.

Vitamin A acetate as produced in this plant has a minimum potency of 2,700,000 U.S.P. units per g. Unfortunately, while this product is ideal from a purity standard, the sensitivity towards oxygen precludes use under normal processing conditions. Therefore, other more practical forms are necessary. Oil-soluble, synthetic vitamin A palmitate of high purity is prepared from the acetate and is available in two forms:

- (1) Synthetic vitamin A palmitate containing 1 to 2% antioxidants—potency at least 1,600,000 U.S.P. units per g.
- (2) Synthetic vitamin A palmitate in corn oil containing antioxidants and standardized at 1,000,000 U.S.P. units per g. for convenience.

In addition, Pfizer has developed a unique dry form of crystalline vitamin A acetate which is stable and will lend itself readily to processing procedures. In this patented process vitamin A acetate is embedded in a gelatin matrix. Contact with air is prevented and hitherto unknown stability is attained. For example, crystalline vitamin A acetate stabilised retains 90% of its potency over a 42-day test period at 45°C., while the pure compound retained only 34% of the original potency at 25°C. over the same test period even when blanketed by an atmosphere of nitrogen. The granules have a potency of 500,000 U.S.P. units per g. and are available in various sizes. All granules are dry and free-flowing for easy handling.



The condensation of formaldehyde and acetone takes place in a series of reaction vessels similar to that shown here.

Plant and Equipment

Stoneware centrifugal pump

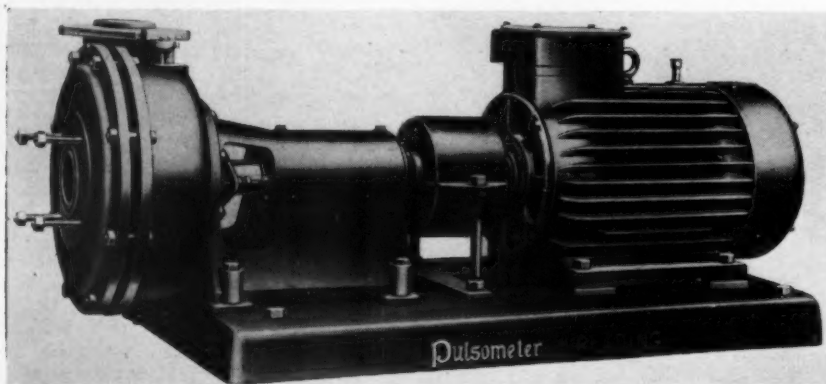
A stoneware centrifugal pump for the chemical and food processing industries has been developed by the Pulsometer Engineering Co. Ltd., in co-operation with Doulton & Co. Ltd. It is specially suitable for pumping acid products such as fruit juices and vinegar, as all parts in contact with the liquid being pumped are of acid-proof stoneware which also does not contaminate the product in any way.

The hood carrying the pump forms a rigid support both for the pump itself and the two bearings, and the shaft is of large diameter, ensuring freedom from vibration and distortion under working conditions. A special grade of corundum stoneware is used for the impeller, which has a low degree of porosity, a smooth, even finish and a high tensile strength. Corundum is much harder than acid-proof stoneware and is completely resistant to all acids, except hydrofluoric, most alkalis, and to all food and chemical preparations for human consumption. The impeller is of the single-inlet shrouded type, securely fixed to the spindle and balanced to run without vibration. The impeller boss extends right through the stuffing box to protect the spindle, and special facings are provided to reduce the pressure on the packing to a minimum.

Additional details include a water thrower and dust cap of the labyrinth type to prevent acid liquid entering the bearing from the gland, whilst each bearing also has grease nipples, and the shaft between is completely protected against any accidental contact with the acid.

Driving can be carried out in any convenient manner, either by direct electric motor drive with flexible coupling, by overhung flat or grooved pulley, or by overhung fast and loose pulley. Direction of rotation also is anti-clockwise when looking towards the driven end.

The pump is produced in three sizes covering quantities from 1-450 gal./hr. and heads up to 140 ft.



Centrifugal pump in acid-proof stoneware.

Flameproof illumination

Victor Products (Wallsend) Ltd. have developed a new flameproof lighting fitting with three main features. A making-up chamber is incorporated in the direct top entry gland, the top cover of the fitting is provided with a small cowl to prevent entry of water at the flange, and the bottom lamp-glass cover has been hinged to simplify lamp replacement. Wiring is by direct top entry or by side entry with a four-way junction box, and the unit is fully Buxton certified.

Process heating equipment

A variety of electrical heating plants and furnaces have been supplied by the General Electric Co. Ltd., England, to the metallurgical and process industries during the past year. These include a new type of continuous decarburising furnace which occupies a minimum of floor space and gives very high processing speeds. A recent installation for continuous decarburisation of silicon steel strip is rated at 620 kW., has a maximum operating temperature of 950°C. and processes strip at about 1 ton/hr.

Another novel continuous furnace, the first to be built in this country, is being supplied to a leading car manufacturer in Paris for the carbo-nitriding of engine gear-box parts.

A large installation of six vertical cylindrical bell-type furnaces anneals silicon steel strip in coils and can process 700 tons/week.

A new roller hearth furnace, 120 ft. long, complete with atmosphere plant and auxiliary drive, has been installed for the bright normalising of steel strip in lengths. The output is 10 cwt./hr.

The use of infra-red heating for drying wood finishes has been applied to furniture, radio cabinets and veneered panels. In an installation at Saro Laminated Wood Products Ltd., panels are sprayed with synthetic resin material and after stoving for 5 to 7 min. a durable fire-resistant plastic



Flameproof lighting fittings.

coating is produced. A similar plant at Jaguar Cars Ltd., Coventry, is used for force-drying the cellulose-base finish applied to the interior woodwork of cars. Drying time is cut from 12 hr. to 9 min. The weekly output is sufficient for 300 complete sets of car woodwork.

Coke oven plant instrumentation

An instrument control panel for the Great Lakes Carbon Co.'s new coke oven plant at St. Louis, Missouri, U.S.A., has been supplied by Bristol's Instrument Co. Ltd., England. The coke oven plant is also being supplied by a British firm.

The instrument control panel is 20 ft. long and 7 ft. high, and incorporates instruments which measure, record and automatically control pressures, temperatures and rates of flow. A number of features of instrumentation and control are used which have never before been applied to coke oven plants and some of the instruments are modifications of latest American designs adopted from Bristol's U.S. parent company.

The instrument panel, which would normally represent one year's work, was completed in six months. It was broken down into units for shipping to the States.

Pinhole detector

A novel detector has been produced for the detection of minute holes in the protective coating of steel pipelines before burial, to enable steps to be taken to prevent corrosion. The detector is manually traversed along the pipe on caterpillar tracks, whose rake is adjustable for pipes of diam. varying between 6 in. and 36 in. In front of the detector is a spring electrode encircling the pipe and maintained at a high electrical potential. The resistance of a sound coating is high enough to prevent any appreciable current passing, but when the electrode reaches a pinhole a continuous spark arcs across to the pipe, causing a warning light to flash and sounding an alarm bell. The spark also burns out the hole, thus rendering it more visible for filling.

For further information on new plant and equipment, please complete the coupon on page 150.

World News

GREAT BRITAIN

Resin cement protection

The successful use of resin cements for protective coatings of fertiliser manufacturing plants by the British Sulphate of Ammonia Federation Ltd., was referred to on p. 94 of last month's issue. INTERNATIONAL CHEMICAL ENGINEERING is now informed that the cement used is phenol-formaldehyde resin cement No. 414 which is supplied by Imperial Chemical Industries, Ltd., together with the appropriate acid hardener. Best results are claimed to have been obtained when using Nori acid-resisting dust as a filler, which is supplied by the Accrington Brick and Tile Co., Ltd.

With regard to the use of protecting lacquers, these are based on PF.414 resin syrup, but are still in the experimental stage.

Smaller sulphur ration for U.K.

The international Materials Conference have announced sulphur allocations for the first six months of this year, the first time that this longer period of allocation has been used. Of a total of 2,953,400 long tons of sulphur, the U.S. gets 2,226,000 tons and the U.K. 194,100 tons. This allocation for Britain compares with 195,000 tons in the first half of last year and 208,600 tons in the second half.

New anodising plant

A new plant has been built at Brimsdon, Middlesex, by Scrib Ltd., for finishing caps and clips, etc., made from aluminium instead of brass, the use of which is now prohibited for these purposes. It is claimed that in appearance the finished metal will compare with gold-plated metal but will cost much less. There are two stages to the process (a) polishing, and (b) finishing, in separate sections of the factory. The first section is equipped with automatic machines for polishing caps and similar objects and the second houses a series of large vats for various finishing processes which include degreasing, anodising and dyeing, with several rinsings between each. All except the cold water vats are fitted with fume extractors linked by trunking to the exhaust fans of an air conditioning plant. Heat for the various stages is supplied by steam coils connected to the boilers. Water, which is used in considerable quantities, is obtained from a well specially drilled for the purpose. The facilities of the plant are available to other manufacturers.

Change of address

Mr. J. A. Radley, chemical consultant, has moved to 220-222 Elgar Road, Reading, Berkshire, where he has a modern, newly-built laboratory for sponsored research and development.



MR. KENNETH GORDON

has been appointed deputy managing director of Head Wrightson Processes Ltd., London. He has been connected with many important developments in the heavy chemical and petroleum industries and has considerable experience in company management.

Mr. John Long, formerly assistant manager of the London office of Head Wrightson & Co. Ltd., has been appointed London manager in succession to Mr. Selby Robson. Mr. Robson remains a director of both companies.

Fluidisation technology conference

A conference on 'Fluidisation Technology,' organised by the Chemical Engineering Group of the Society of Chemical Industry will be held in London on June 12 and 13. The arrangements for the conference are not yet complete, but it is expected that at least 12 papers will be read and a dinner to the foreign delegates will be arranged. Further details are available from the Secretary, Chemical Engineering Group, 56 Victoria Street, London, S.W.1.

Price changes

Lead.—The price of imported good soft pig lead has been cut from £175 to £170 per ton delivered consumers' works, according to a Ministry of Materials statement.

Magnesium.—The price of virgin magnesium in ingot form has been raised from 2s. 4½d. to 2s. 10½d. delivered consumers' works, according to a similar Government announcement.

Fertilisers.—The permitted maximum prices of fertilisers were increased last month owing to the higher costs of sulphuric acid, bags, transport, coal and wages. Examples of the price increases (per ton) are: sulphate of ammonia, from £15 15s. by £1 3s. to £16 18s. for not less than 6-ton lots; ground phosphate, 29% P₂O₅ content, from £12 2s. by 9s. to £12 11s.; nitro-chalk, from £14 11s. by £1 2s. to £15 13s. The prices of basic slag, muriate and sulphate of potash remain unchanged.

South African branch of I.Chem.E.

The president of the Institution of Chemical Engineers, Sir Harold Hartley, has accepted the invitation of the Van Riebeeck Festival Committee and of the South African Government to visit South Africa for the Tercentenary Celebrations. While in Johannesburg this month (March) he hopes to take the chair at a meeting which it is proposed to call to inaugurate a South African branch of the Institution.

Zinc Pigment Development officers

Officers of the Zinc Pigment Development Association Council for 1952-53 are: J. M. Brown, James M. Brown Ltd., chairman; J. F. E. Ruffell, Durham Chemicals Ltd., and H. L. Whitworth-Jones, Imperial Smelting Corp. Ltd., deputy chairman.

Treating tower for Llandarcy refinery

The treating tower for the propane desasphalting unit, which forms part of the extension of the Llandarcy (South Wales) plant of the National Oil Refineries Ltd., weighs about 130 tons and is 70 ft. long and 12 ft. in diameter. Since the tower has to work at a pressure between 500 and 600 p.s.i., making a total pressure of over 90,000 tons on the internal surface at a temperature above 200°F., the 2½ in. thick high-tensile steel plates, from which it is rolled, had to be united by a special fusion welding process which, the suppliers, Babcock & Wilcox Ltd., developed for high-pressure boiler drums. While it is by no means impossible to carry out this and/or ancillary operations on site, the difficulties involved were such that it was decided to accept the problem of one-piece transport.

However, the tower is of such a size that long-distance road or rail travel was impracticable and the major portion of the journey was by sea. Special measures needed for this job included the use of a specially fitted tank landing craft, the employment of twin floating cranes lashed together (one being towed specially from Cardiff docks), the employment of special railway vehicles for a one-mile journey, the shoring-up of a road bridge and the laying of steel decking roads.

Institute of Metals' officers

Officers of the Institute of Metals for 1952-53 are Dr. C. J. Smithells, British Aluminium Co. Ltd., president; G. L. Bailey, British Non-Ferrous Metals Research Association, and Dr. S. F. Dorey, Lloyd's Register of Shipping, vice-presidents; and E. H. Jones, Capper Pass and Son Ltd., hon. treasurer.

Metallurgy essay prizes

The Council of the Institute of Metals will present annually two prizes of 20 guineas each for the best essays on set subjects. For the 1952 competition, candidates may select from two subjects: Non-Ferrous Foundry Practice and Metallurgy in Industry. Closing date is May 19.

Fuel saving team to U.S.A.

A specialist team concerned with conservation of fuel recently went to the U.S.A. under the leadership of W. L. Boon, of Powell Duffryn Technical Services Ltd. Nominations to the team were made by bodies representing the engineering, heating and ventilating, cotton, woollen, brewing, chemical and paper industries in this country; the T.U.C.; the British Coal Utilisation Research Association; and the Institute of Cost and Works Accountants.

Furnace industries and those depending largely on coal as a raw material (*e.g.*, iron and steel, gas, electrical power generation, pottery, etc.) are expressly excluded from the enquiry, and domestic heating (as distinct from strictly commercial applications) will only be studied in so far as its demands impinge on the peak load of electricity supply undertakings.

The conservation of fuel being bound up with the original means of application of heat and energy, in whatever form except water power, the team's tour in America will take in power installations of diverse kinds in a variety of industries, besides firms manufacturing ancillary equipment, such as automatic control, the utilisation of exhaust steam through back-pressure generation and so forth.

Metallurgy awards

Mr. W. S. Robinson, until recently president of the Consolidated Zinc Corp. Ltd., has been awarded the Platinum Medal of the Institute of Metals for 1952 in recognition of outstanding services to the non-ferrous metal industries in developing the Australian zinc-lead industry and the British zinc industry. Other medallists were Prof. A. Guinier, Conservatoire National des Arts et Métiers, Paris, who received the Rosenhain Medal, and Mr. C. E. Davies, who received the W. H. A. Robertson Medal.

Coal gas manufacture

A course of 16 lectures on this subject is being given at Leeds University. Sections, which may be taken separately, yet to be given are Section (D), March 10, 'Economics of the Gas Industry,' by Dr. R. S. Edwards, 2 p.m. and 3.30 p.m., and Section (E), March 17, 'Refractory Materials,' 2 p.m. and 3.30 p.m.

Personal

Mr. F. George has joined Refractory Mouldings and Castings Ltd. as a director and has severed all connection with Zirconal Ltd. with whom he was a director for four years.

Deaths

We regret to announce the deaths of: Mr. C. J. T. Mackie, assistant secretary to the Institution of Chemical Engineers, who died on January 8. Mr. Mackie had held this position from the time he first joined the Institution in 1924. He par-

ticipated in the growth and increase in prestige of the Institution from quite small beginnings and he gave devoted service. His wife and daughter survive him.

Mr. Raymond C. Gaugler, president of American Cyanamid Co., who died in New York on January 11. He was born in Pittsburgh and graduated from Duquesne University. Before joining Cyanamid he was with United States Aluminium Co. and the Northern Aluminium Co. He came to Cyanamid in 1917, and was successively assistant treasurer and comptroller, treasurer, vice-president in charge of finance, executive vice-president and then president. He was also a director of several associate companies.

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CZECHOSLOVAKIA

Exports to Finland

Under an agreement recently signed in Prague and covering the whole of this year, Czechoslovakia will export chemical and pharmaceutical products, fire-resisting clay and sugar, among other items, to Finland. Some of the Finnish exports to Czechoslovakia include copper, nickel sulphate and cellulose. The value of the trade between the two countries is expected to reach approximately £2,000,000 in each direction.

FINLAND

First nitrogen factory

Finland's first nitrogen factory, now under construction at Uleaborg, West Finland, is expected to start production next July. The yearly output will be 16,000 tons of nitrogen, or about 80% of Finland's present requirements.

HOLLAND

Ceramic magnets

Development of a new material for permanent magnets has been reported at a meeting of the Netherlands Physical Society. Called *Ferroxdure*, it has been developed by the Philips research laboratories at Eindhoven. The product is a ceramic, and in structure and composition differs greatly from the traditional magnet steels, it was stated. Its properties were said to offer many new possibilities for the application of permanent magnet materials.

Cobalt and nickel are not required in the manufacture of *Ferroxdure*, which is produced by sintering or firing, like chinaware. It is described as an oxide, and contains iron and barium.

GERMANY

Chemical company formed

Almost all war damage to the Badische Anilin-und Sodafabrik A.G. works at Ludwigshafen has been repaired, and last year its total output was valued at 680 million DM, about one-third of which was exported. This company used to belong to the I.G. Farben organisation which was split up after the war into separate and smaller companies. More recently allied control of the B.A.S.F. was ended and a new company was formed. Its initial capital of 100,000 DM will be raised later. This is the third successor company to I.G. Farben to be set up.

New coal and iron company

A new company, Nordwestdeutsche Hütten-und Bergwerksverein A.G. has been set up at Duisberg in the Ruhr under the reorganisation plan for the German heavy industries. It has an initial stock capital of DM 88,000,000 and owns all the shares in several coal mines and iron works which were formerly part of Kloeckner-Werke A.G., now in liquidation. The companies controlled by the new holding company employ about 29,000 persons. Their steel production capacity is about 1,200,000 tons p.a. and hard coal production in 1951 was about 2,200,000 tons.

Phosphorus output increased

The Western Allies have authorised an increase in West Germany's production capacity of white phosphorus from 4,500 to 6,100 tons yearly. The Allied Military Security Board is issuing a licence to the Lonzawerke Elektrochemische Fabriken of Waldshut, Baden, for the installation and operation of a plant to produce 1,500 to 1,800 tons yearly.

West Germany's current 4,500 tons capacity is covered by a licence granted to the A.G. für Stickstoffdünger, Knappsack, Cologne.

FRENCH WEST AFRICA

Fibre and plastic made from castor-beans

A French firm in French West Africa has developed a new superpolyamide from castor-beans; it is called *Rilsan* and can be produced as a plastic or fibre. Two plants for its production have already been built and a third is under construction.

It is estimated that the annual consumption of castor-beans could be about 9,000 tons. To obtain this quantity, the company is encouraging cultivation of castor-beans in the French Union where climatic conditions are particularly favourable, principally in Morocco, French Guinea, Senegal, and French Equatorial Africa. Seeds have been distributed free of charge and efforts are being made, through a firm in Conakry, to contract for the purchase of castor-beans, at a fixed price for the next five years, from growers in French Guinea.

FRANCE

Asbestos factory established

An asbestos works has been established near Château-Queyras, about 20 miles from the Italian border. Work at the Péas mine began in 1928, but was later abandoned for a number of years. Reopened in 1947 and equipped with modern plant, the works will be able to treat 400 to 500 tons/day of asbestos ore, equivalent to 12-15 tons of fibres and 40-50 tons of shorts and floats.

Chemical patents for Japan

The French chemical firm Usines de Melle has recently concluded a contract with two Japanese firms under which they will use the French company's patents. A 15 years' contract was concluded with the Kurashiki Rayon Co. which recovers acetic acid and a contract of 2 years with the Nippon Jorgu Kogyo K.K. which makes plant for the chemical industry.

The French company already holds 51% of the capital of the Jorgu Kogyo Company.

NORWAY

Norsk Hydro's good year

Norsk Hydro, Norway's largest chemical concern, had a record production in the 1950-51 financial year, according to the annual report recently published. The output of pure nitrogen was 165,000 tons, equivalent to 1,065,000 tons of nitrate of lime.

The company's income was £13,800,000 as against £10,650,000 in 1949-50 and £7,900,000 in 1948-49. At the annual meeting of the company, the director-general said the board had decided to give workers a bonus of £20 each and donate £75,000 to scientific research funds.

New iron works

A Norwegian company, A/S Titania, plans to build a smelting works for pig iron at Sokndal. A new method will be used for extracting the 30% of iron contained in ilmenite, and an output of 30,000 tons of pig iron is estimated, if sufficient electric power can be obtained.

Plenty of atomic fuel

Contrary to popular belief, atomic fuel is not expensive and exists in enormous quantities according to Hr. Odd Dahl, Norwegian engineer and head of the Department of Applied Physics at the Chr. Michelsen Institute, Bergen.

Norway, he said, was one of the countries possessing relatively abundant deposits of medium or low content uranium ore, and these would become important when the relatively rich deposits elsewhere were exhausted.

Hr. Dahl emphasised that ships powered by atomic energy were today within the

range of possibility, and displayed diagrams of atomic engines which were already feasible. He added that the U.S. Atomic Energy Commission had estimated that the world atomic fuel reserves were 600 times larger than the reserves of coal and oil.

AUSTRIA

Tin salts output

A Tyrolean firm is now producing high-quality tin salts in quantities sufficient to cover domestic requirements. Output of tin chloride has already reached a high level and 50% of the raw materials used in its production are of local origin. The firm recently began producing sodium stannate.

PAKISTAN

Vegetable oil factory

Pakistan's Prime Minister has opened a new £1,500,000 vegetable oils factory at Rahimyar Khan in Bahawalpur State. The factory is being built with the aid of capital and technicians from the British firm Unilever Ltd. The factory, known as Sadiq Vegetable Oils and Allied Industries Ltd., will turn out edible oils, soap, glycerine and cattle fodder from cotton seed.

JAPAN

Soap plant expands

The Nihon Yushi Co. Ltd., of Tokyo, one of the largest soap makers in the Far East, will use the services of the American company, Blaw-Knox, to expand its facilities by installing a modern 50-ton/day plant for fat splitting.

The contract covers the engineering design and procurement of equipment for this new fat-splitting plant, as well as the use of licensed processes.

MOROCCO

Uranium from phosphates

Appreciable quantities of uranium have been found in the almost inexhaustible supplies of Moroccan phosphates according to Col. Pommerie, Director of Industrial Production in Morocco. If the extraction of uranium from phosphates became commercially practical, unlimited possibilities would be opened as local phosphate production now amounts to 4,700,000 tons p.a., a figure which is actually limited by an agreement with other North African producers.

Uranium is to be recovered as a by-product in a new \$10,000,000 phosphate plant to be built by International Minerals and Chemical Corporation in Florida (see INTERNATIONAL CHEMICAL ENGINEERING, 1951, August, p. 393). This plant is scheduled to go into operation this year and will produce 100,000 tons of defluorinated phosphate p.a.

ISRAEL

Asbestos works

An asbestos works is to be erected in the industrial zone of Acre. It will consist of two distinct plants, one for manufacture of pressure pipes and the other for the manufacture of soil pipes. The first plant has been ordered from a Swiss firm, and the latter plant has already arrived in Israel from Italy.

Cellulose company planned

An Israeli company for the manufacture of cellulose is being planned, following successful experiments on local vegetation by the Government Research Council. It is believed that several international companies are willing to invest in the new company and to buy its output.

INDIA

Salt cake for glass manufacture

One of the by-products of salt manufacture in the Rajasthan area, and particularly at Didwana, is salt cake. This material, which is available in abundance, has so far only found limited uses. Recent work at the Central Glass and Ceramics Research Institute shows it is possible to use salt cake to replace part of the imported soda ash in the manufacture of amber glass. The possibility of extending the practice to ordinary glass manufacture is under investigation. Adoption of this practice will result in an appreciable reduction in the import of soda ash and of sulphur for the manufacture of amber glass.

Calcium carbide production started

A factory for the manufacture of calcium carbide has begun operating at Talayuthu, Tirunelveli District, Madras State. It will have a production capacity of 70 tons per month.

India now imports nearly 10,000 tons p.a. of calcium carbide from Canada, Africa and Norway for use in the coal fields, lighting purposes, in oxy-acetylene cutting and welding.

The factors that are favourable to the starting of the factory at Tirunelveli are local supplies of pure lime-stone and the facility of sea transport of coke from Bengal, which can be unloaded at Tuticorin port.

Electrolytic clarification of sugarcane juice

Research on electrolytic clarification of sugarcane juice which is likely to be of considerable value to the Indian sugar industry, has recently been carried out by Prof. D. N. Ghosh, Patna Science College.

If the method of electrolytic clarification is successfully introduced the factories will be freed from their dependence on the use of sulphur for the clarification of cane juice. This method is also claimed to give

higher sugar recoveries at lower cost and a relatively more edible type of molasses.

Satisfied with a laboratory demonstration given at the Indian Institute of Sugar Technology, Kanpur, the Government of India have given Rs. 10,000 for full trials at the experimental sugar factory attached to that Institute.

Sugar factories in India use sulphur for the clarification of cane juice. During World War II the import of foreign sulphur was cut off. The factories, therefore, were faced with a difficult situation which was somehow tided over by the use of low-grade Baluchistan (Pakistan) sulphur. But after partition, even this source of supply is no longer available to India.

AUSTRALIA

Largest refinery planned

A £40,000,000 refinery for processing 3,000,000 tons of Middle East crude oil annually is to be built at Cockburn Sound, near Fremantle, by the Anglo-Iranian Oil Co. This will be the largest refinery in Australia and will employ about 1,000. It is estimated that construction of the refinery will provide employment for up to 4,000 men for three to four years. The refinery will have substantial catalytic cracking capacity.

Australia's present consumption of petroleum products is 5,500,000 tons p.a., but local refinery capacity is only 900,000 tons, or approximately 16% of consumption. By 1956 consumption will probably be 7,500,000 tons p.a., by which time production capacity will also be about 7,500,000 tons p.a.

German plastics factory

A German plastics factory is being completely dismantled and will be established and in production in Adelaide before the end of this year. This was stated in Sydney by Mr. Stephen Merko, an Adelaide businessman who returned from Germany by air after making the necessary arrangements.

Mr. Merko said the factory, Rehauer Plastics, was being shipped to Australia together with eight of the workmen and their families. Eighty tons of machinery, as well as the steel building, would be sent out.

CANADA

N.R.C. chemical research

During 1951 three new laboratories were equipped and put into operation for process development work, radioactive tracer studies, and enzymology, at Saskatoon, Saskatchewan, by the Prairie Regional section of the Canadian National Research Council which was set up in 1948 to study industrial utilisation of farm products.

Ustilagic acid, the new antibiotic produced by fermenting sugars with corn-smut fungus, is now being produced in 200-gal. fermentors in the pilot plant laboratory. This has been used for growth

The Leonard Hill Technical Group

Articles published in some of our associated journals in the Leonard Hill Technical Group this month include:

Manufacturing Chemist—Combination of Synthetic Detergents; Practical Possibilities of Ion Exchange, Part I; Progress Reports on Analytical Chemistry and Economic Poisons.

Food Manufacture—Mould Contamination in Pork Pie Manufacture; The Baking Industry, The Vitamins, Part II.

Petroleum—Corrosion of Buried Metals; Pattern of the Oil Industry; Catalyst Plant.

Paint Manufacture—Examination of Varnish Making Vegetable Oils; Codifications of Synthetic Resins; Whiting in the Paint Industry.

Atomics—Million-Volt H.T. Accelerator; Atomic Energy Instrumentation.

World Crops—Vegetable Fats and Oils; Maintenance Problems solved by Welding; Farm Electrification in the Western Prairie States.

Muck Shifter—Piling in Civil Engineering; Russia's Giant Draglines.

Building Digest—Acoustics in Auditoria.

Pottery and Glass—Domestic Pottery Today.

stimulant tests on chickens with positive results and it appears that it might be used as a starting material for the preparation of synthetic musks for use in perfumes.

Structural fibre boards have been prepared from wheat straw by a wholly mechanical process. These boards are superior in strength, density and general properties to commercial boards made from wood fibres. Laboratory studies currently underway indicate that by a relatively simple treatment these boards may be made with better moisture-resisting properties and enhanced dimensional stability.

The composition of rapeseed oil has been accurately determined and a technique of fractionating this oil is being critically studied. Engineering data, which will enable a processor to set up equipment and cut definite fractions, have been obtained. Fractions low in iodine value should have superior properties in the preparation of marine engine lubricating oils, while those of higher iodine value, when blown, find uses in lacquers, patent leathers, etc. A promising lead has been found which may result in lowering the cost of fractionation of vegetable oils.

Towards sulphur self-sufficiency

New projects are expected to balance supply and demand for sulphur in Canada by the end of this year. A new Shell Oil plant for the production of elemental sulphur has just gone into action at the company's natural gas field at Jumping Pound, Alberta. The unit cost \$500,000 and will recover 10,000 tons of elemental sulphur annually from waste acid gases of the gas-scrubbing plant. Sulphur of up to 99.9% purity can be produced by the process adopted. The process was introduced into North America in 1946 by the Southern Acid and Sulphur Co. of McKamie, Arkansas, U.S. A great advantage in this field is the unusually high hydrogen sulphide content of the natural gas.

A similar project is to be undertaken by the Royalite Gas Co., at its Turner Valley gas field. It will be opened in April and will produce about 9,000 long tons of elemental sulphur annually. In both cases the sulphur will be used by Western producers of paper and pulp.

Other projects for increasing Canada's sulphur supplies are being undertaken by the following companies:

A \$4,000,000 plant to treat some 300 tons of iron pyrites daily is in the planning stage by Noranda Mines. It will produce some 60 tons of elemental sulphur and 200 tons of iron sinter daily.

Canadian Industries Ltd.: Facilities at Copper Cliff, Ontario, are being expanded to produce 90,000 tons of liquid SO₂ annually.

Aluminium Co. of Canada plans a mid-1952 opening of its plant at Arvida, Quebec. It will produce 45,000 tons of sulphuric acid annually.

Part of a \$9,000,000 fertiliser plant to be built by Consolidated Mining and Smelting Co. at Kimberley, British Columbia, will be a modern sulphuric acid plant with a capacity of about 110,000 tons yearly.

In addition, the Nichols Chemicals Co. will double its existing yearly output of 100,000 tons of sulphuric acid when its new plant opens in May, while Britannia Mining and Smelting has a 100,000-ton stockpile of pyrites at Howe Sound, British Columbia, which may be utilised for the West Coast paper and pulp mills.

Some of these and other sulphur projects were referred to in INTERNATIONAL CHEMICAL ENGINEERING, 1951, pp. 290, 340, 394, 596, and 1952, p. 45.

New woodpulp mill planned

The Canadian Celgar Development Co. Ltd. plans to embark soon on a wood pulp and newsprint development scheme in the Arrow Lakes region of South-Eastern British Columbia. The project, which would cost \$65,000,000, calls for the construction of two, and possibly four, mills near Castlegar, roughly 250 miles east of Vancouver in the West Kootenay area.

The company, which is affiliated to the Celanese Corporation of America, said the development would ultimately mean employment for more than 2,000 people.

Pipeline for metal concentrates

The International Nickel Co. has completed a 7½-mile pipeline through which bulk concentrate from 3,650,000 tons of nickel-copper ore is being pumped annually from its newly built Creighton concentrator to its reduction plants at Copper Cliff, Ontario. It is believed that never before has concentrate been carried by pipeline in such quantity over such a distance.

'The pipeline reduces the time required to transform nickel ore into refined nickel,' Mr. Beattie, vice-president and general manager, said. 'Further, the economies resulting from pipeline transportation, together with other economies, have made possible the working of lower Creighton ore which is now contributing to the nickel supplies for defence production needs.'

U.S.A.

Formaldehyde improves petrol

Formaldehyde treatment of fuels leads to the production of superior motor and aviation spirits, according to a statement by a representative of the Esso organisation to the American Chemical Society. Improved engine performance in terms of better susceptibility to anti-knock agents and less engine corrosion, as well as smaller losses in petrol manufacture and less gum formation during storage, were said to be advantages of the new process.

New Gulf Oil units

Contracts have been awarded by the Gulf Oil Corp. for the construction of a new sulphuric acid plant and a polymerisation unit at Port Arthur, Texas. Completion of both projects is scheduled this year. The acid plant, with a capacity of 300 tons daily, will increase capacity of the Port Arthur refinery by 150%, it is stated. It will also make sulphur by catalytic action. The new polymerisation plant will make a high octane petrol from propylene, a gaseous petroleum product.

New plastic material

The U.S. Atlantic Refining Co. is now marketing a new low-priced thermoplastic resin, produced in its Philadelphia refinery. The new product, called SP asphalt resin, is obtained from petroleum.

It can be used in the manufacture of asphalt tiles, for the internal sizing of kraft paper, in sealing compounds and adhesives, for waterproofing, to impart tackiness to synthetic rubbers and as a plasticiser and extender for rubber compounds except in cases where a light colour is important. It is dark-coloured neutral hydrocarbon compound, containing no free carbon and almost free from ash.

More synthetic catalysts

Production facilities at the recently built American Cyanamid plant in Michigan City, Indiana, will be expanded in order to increase sharply the output of synthetic cracking catalyst, used by oil refiners in making high octane petrol. Expansion work at the plant, whose sole output is this catalyst, will be completed by mid-summer. The new production rate will be sufficient to serve a refining capacity of 800,000 barrels daily.

More aniline needed

The U.S. Defence Production Administration has announced a goal to expand domestic aniline production to 135 million lb. p.a. by 1954. The new goal represents a 26% increase over U.S. aniline capacity of 106.4 million lb. as of January 1 last year.

Expansion of U.S. capacity to produce aniline has become necessary because of the large quantities of the chemical required for rubber processing. About 54% of U.S. aniline production is used in the manufacture of rubber chemicals, while 22% is used in the production of dyestuffs.

Of the 28.6 million lb. of additional aniline capacity expected by 1954, about 13 million will be provided by private firms without Government aids. The remainder will be brought in by private firms which have received fast tax write-off allowances on their new production facilities, D.P.A. added.

Sulphur production aid

Increased output of ethanolamine has been authorised at the Dow Chemical Co.'s facilities and may be an important factor in bolstering dwindling U.S. natural sulphur reserves, according to a Dow official. Ethanolamine is being currently used by several of the company's customers to remove sulphur from natural gas and, in some instances, this sulphur is being converted to sulphuric acid.

Sulphur production target

The Defence Production Administration has set a target for sulphur production of 8,400,000 long tons p.a. by 1955. This amounts to an increase of 2,320,000 long tons or 38% over 1950 U.S. sulphur production of 6,080,000 tons.

The D.P.A. said that existing Government and private industry expansion schemes will increase production by 1,080,000 tons at the beginning of 1955. The new target calls for an additional 1,250,000 tons by 1955.

D.P.A.'s expansion schemes are based on two factors—a reduction in sulphur exports as new foreign sources are developed, and an increase in home production by developing new sulphur domes and recovering increased amounts of sulphur from petroleum, natural gas, domestic and imported pyrites and smelter acid.

The expansion in sulphur capacity already begun calls for an increase of

520,000 tons by private industry without Government assistance, plus the following programmes with Government aid: 690,000 tons of native sulphur from new domes; 280,000 tons from petroleum and natural gas; 170,000 tons from private pyrites; 100,000 from smelter acid; and 10,000 tons from other sources. This amounts to a gross increase of 1,770,000 tons, but D.P.A. estimates that production from existing sulphur facilities will decline by about 690,000 tons by 1955. This leaves a net increase of 1,080,000 long tons.

Sulphur and sulphuric acid restrictions

A recent order by the National Production Authority restricts consumption of sulphur to 90% of amounts used in 1950 and sets up machinery for supplying military and defence requirements by means of directives to sulphur suppliers.

The allocation of sulphur is based on a new N.P.A. estimate of domestic production at 5,200,000 tons, some 200,000 tons higher than that of the producers. The N.P.A. said that this higher estimate, which makes for a relatively high usage rate, eliminates the need for specific limitation of the end uses of both sulphuric acid and carbon bisulphide, because restriction of the use of sulphur will automatically limit the amount of sulphuric acid and carbon bisulphide which a company may produce.

MEETINGS

Institution of Chemical Engineers

March 8. 'Liquid/Liquid Extraction in Laboratory and Pilot Plant,' by J. F. Short and P. Eaglesfield, 3 p.m., Latin Theatre, the University, Edmund Street, Birmingham.

March 11. 'Pneumatic Conveying of Solids,' by Prof. D. M. Newitt, G. F. Hillyar Russ and R. H. Clarke, 5.30 p.m., Geological Society, Burlington House, Piccadilly, London, W.1.

March 26. 'Construction and Personnel Planning of the Esso Refinery, Fawley,' by G. Noble, 6.30 p.m., Mason Theatre, the University, Edmund Street, Birmingham. Joint meeting with the S.C.I.

April 1. Symposium, 'Standardisation of Stainless Steels,' 5.30 p.m., Geological Society, Burlington House, Piccadilly, London, W.1.

GRADUATES' AND STUDENTS' SECTION

March 10. 'The Good Life for a Chemical Engineer,' by W. N. Hoyte, 6.30 p.m., Council Room, the University, Edmund Street, Birmingham. Joint meeting with the Institute of Petroleum.

March 20. 'Design of Plant for the Conservation of Sulphur and Sulphuric Acid,' by J. M. Solbett, 7 p.m., College of

Technology, Great Horton Road, Bradford.

March 21. 'Design of Bubble Cap Distillation Columns,' by D. C. Freshwater, 6.30 p.m., Caxton Hall, London, S.W.1.

March 27. 'Fluid Catalytic Cracking Process,' by J. G. Lucas, 7 p.m., Queen Hotel, City Road, Chester.

Chemical Society

March 7. 'Development of Organic Chemistry during the 20th Century,' by Sir Ian Heilbron, 5.30 p.m., Chemistry Department, University College, Swansea.

March 7. 'Recent Advances in Nucleotide Chemistry,' by Prof. A. R. Todd, 8 p.m., Chemistry Department, Trinity College, Dublin.

March 13. 'Modern Developments in the Use of Fertilisers,' by Dr. G. W. Cooke, 6.30 p.m., Grimsby.

March 14. 'Combination of Metals and Non-Metals,' by Dr. U. R. Evans, 5.30 p.m., Chemistry Department, University College, Swansea. Joint meeting with the R.I.C.

March 14. 'Formation of Hydrogen Atoms in Aqueous Solution,' by Prof. F. S. Dainton, 4.30 p.m., Chemistry Lecture Theatre, the University, Birmingham.

March 27. All-day symposium, 'Ion-Exchange Resins.' Joint meeting with the R.I.C., S.C.I. and Institute of Physics.

March 27. 'Chemical Exploration of the Stratosphere,' by Prof. F. A. Paneth, 7.30 p.m., Burlington House, Piccadilly, London, W.1.

Society of Chemical Industry

March 7. Chemical Engineering Group symposium, 'Mechanical Properties of Plastics,' 10 a.m. and 2 p.m., Institution of Electrical Engineers, Savoy Place, London, W.C.2.

March 14. Corrosion Group symposium, 'Protective Coatings under Conditions of Atmospheric Corrosion,' 10 a.m. and 2.30 p.m., Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W.1. Joint meeting with the Association Belge pour l'Etude, l'Essai et l'Emploi des Matériaux.

Institute of Fuel

March 7. 'Power in the Future,' by Dr. J. Bronowski, 7.15 p.m., Loughborough College.

March 11. 'Modern Outlook on Refractory Materials,' by Dr. A. T. Green, 7 p.m., Midlands Electricity Board Lecture Hall, Kingsway, Stoke-on-Trent. Joint meeting with the North Staffordshire Fuel Society.

March 10. 'The Heat Pump,' by L. Nichols, 6.30 p.m., King's College, Newcastle.

March 18. 'Fuel, Heat and Power Auditing,' by L. Clegg and J. Price Walters, 5.30 p.m., Institution of Mechanical Engineers, Storey's Gate, St. James' Park, London, S.W.1.

March 19. Discussion, 'Research into Steam and Heat Utilisation in Industry,' opened by Prof. E. G. Ritchie, 6.30 p.m., Engineers' Club, Manchester.

March 19. 'Some Relations between Atomic Energy Developments and the Fuel Industries,' by J. M. Hutcheon, 6.30 p.m., the University, Leeds.

March 20. 'Chemical Aspect of Low-Temperature Carbonisation,' by G. S. Pound, 7.15 p.m., Electricity Theatre, Irongate, Derby. Joint meeting with the R.I.C. and S.C.I.

March 21. 'Aspects of Complete Gasification of Coal,' by Dr. F. J. Dent, 7 p.m., Royal Technical College, Glasgow.

March 28. Annual general meeting and discussion on 'Research into Steam and Heat Utilisation in Industry,' opened by Dr. E. G. Ritchie, 2.30 p.m., Radiant House, Bold Street, Liverpool.

April 2. 'Possible Applications of the Heat Pump,' by J. Sumner, 6 p.m., Grand Hotel, Colmore Row, Birmingham 3.

Institute of Petroleum

March 12. 'Alcohol Motor Fuels,' Part I, 'Economics,' by T. C. Owtram, Shell Petroleum Co., Part II, 'Manufacture and Use,' by S. J. W. Pleeth, Cleveland Petroleum Co. Ltd., 5.30 p.m., Manson House, 26 Portland Place, London, W.1.

March 26. 'Comparison of "Slurry," Fluidised Bed and Fixed Bed Operation in the Fischer-Tropsch Process,' by Dr. C. C. Hall, Fuel Research Station, 5.30 p.m., Manson House, 26 Portland Place, London, W.1.

Royal Institution

March 14. 'Alchemy and Art,' by Prof. J. Read, 9 p.m., 21 Albemarle Street, London, W.1.

Royal Society of Arts

March 19. 'Supplementary Sources of Power—Wind, Tide, Sun and Volcanic Heat,' by C. W. Marshall, British Electricity Authority, 2.30 p.m., John Adam Street, Adelphi, London, W.C.2.

Fertiliser Society

April 3. 'Aspects of Mechanical Handling in the Fertiliser Industry,' by J. A. P. Macdonald, 2.30 p.m., North British Hotel, Edinburgh.

Institute of Metals

March 24. 'Place of Plastics in the Order of Matter,' by Dr. J. J. P. Staudinger, 6 p.m., Royal Institution, Albemarle Street, London, W.1.

March 25-27. Annual general meeting presidential address, symposium. 'Equipment for the Thermal Treatment of Non-Ferrous Metals and Alloys,' Park Lane Hotel, and 4 Grosvenor Gardens, London, S.W.1.

Hull Chemical and Engineering Society

March 25. 'Film evening, 'Boilers and Combustion,' by International Combustion Co. Ltd., 7.30 p.m., Church Institute, Kingston-upon-Hull.

Institution of Works Managers

March 11. Film, 'Atomic Physics,' 6.30 p.m., Adelphi Hotel, Liverpool. Jointly with the Institution of Production Engineers.

March 11. 'Initial Training of a Young Graduate,' by A. Fairbairn, Ministry of Supply, 7 p.m., Starkie House, Starkie Street, Preston.

March 13. 'Merit Rating and Job Evaluation,' by J. C. W. Stead, Bachelors Peas Ltd., 7.15 p.m., Royal Hotel, Bristol.

March 17. 'British and American Industrial Relations,' by T. G. Belcher, American Vice-Consul, Glasgow, 7.15 p.m., Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2.

INTERNATIONAL CONFERENCES

March 23-27. The 121st national meeting of the American Chemical Society, Buffalo, New York.

March 30-April 3. The 121st national meeting of the American Chemical Society, Milwaukee, Wisconsin.

April 3-8. Physical Society Exhibition and Conference, Imperial College, London. Secretary: 1 Lowther Gardens, London, S.W.7.

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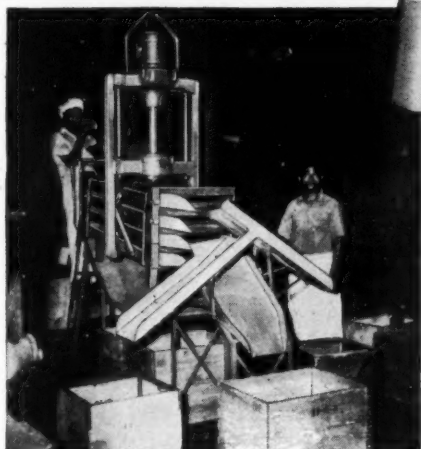
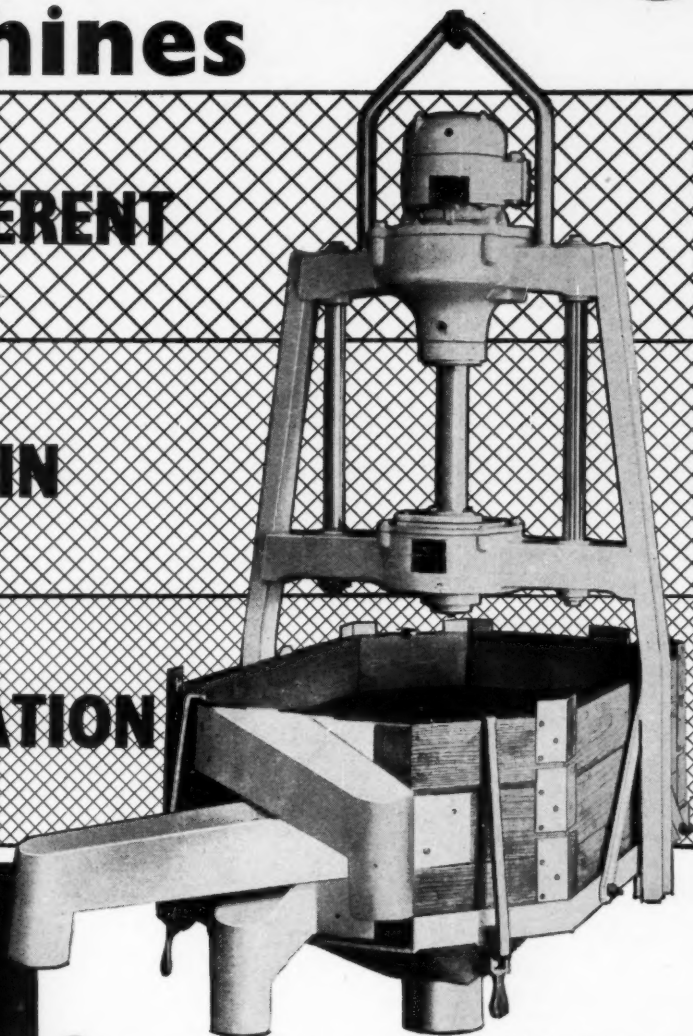


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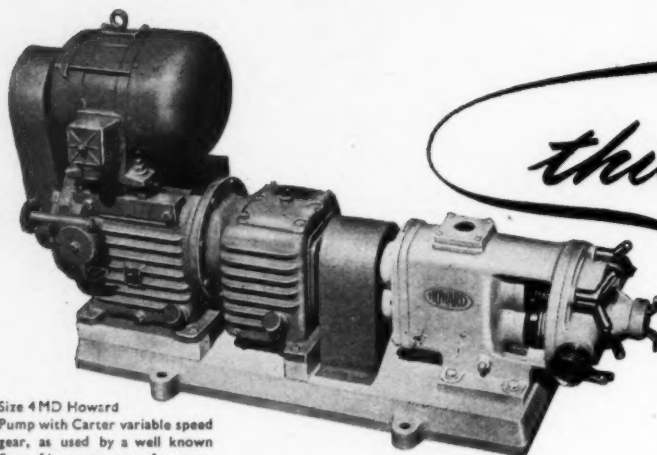
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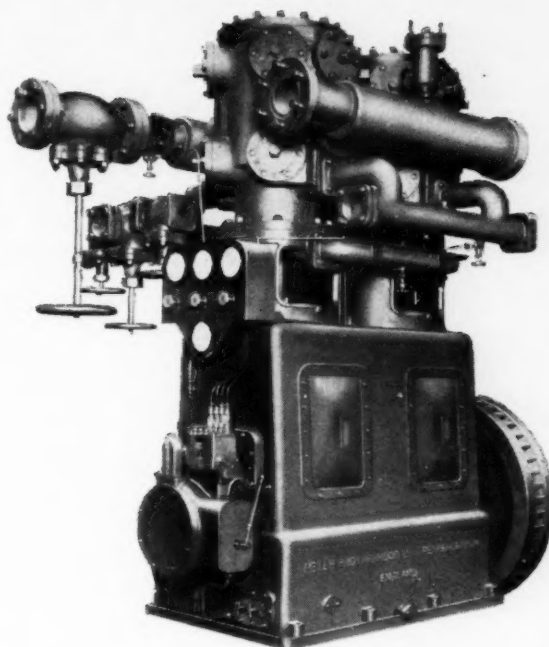
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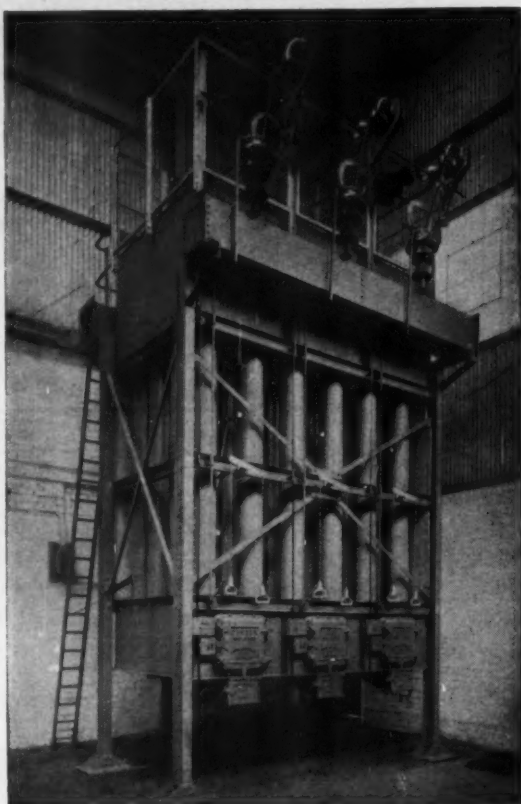
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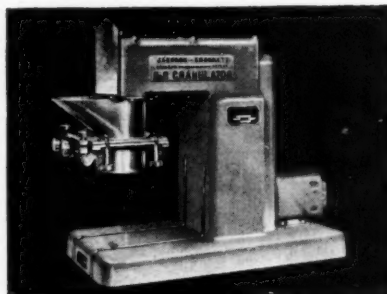
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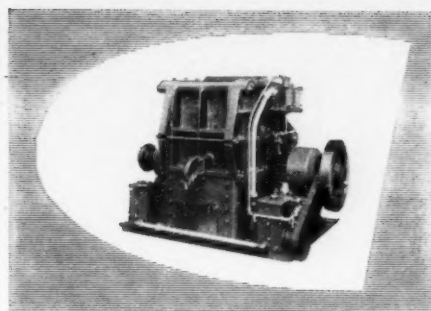
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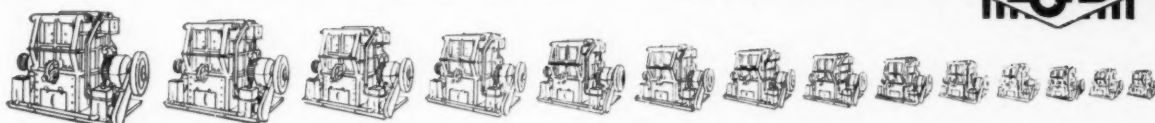
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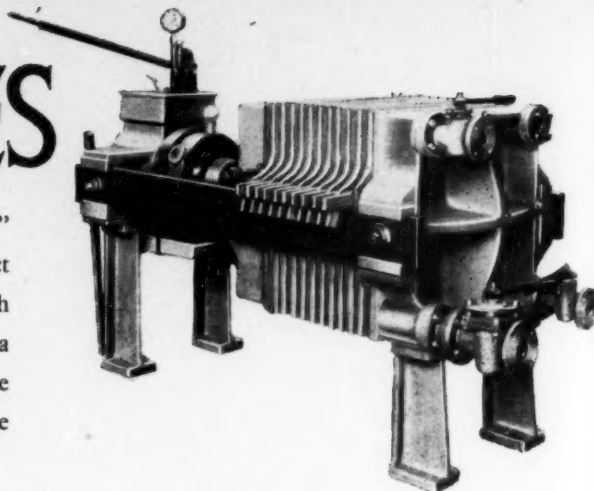
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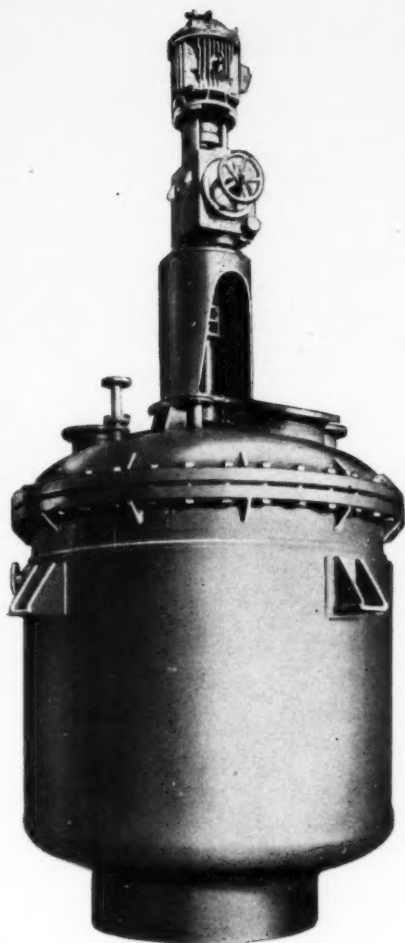
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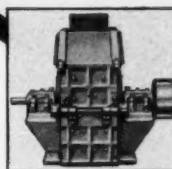
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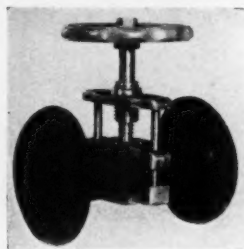


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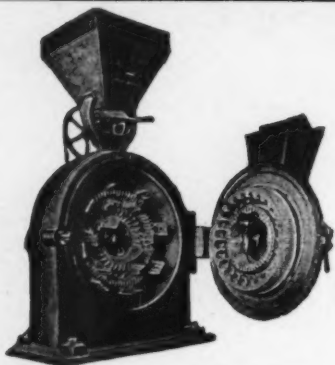
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